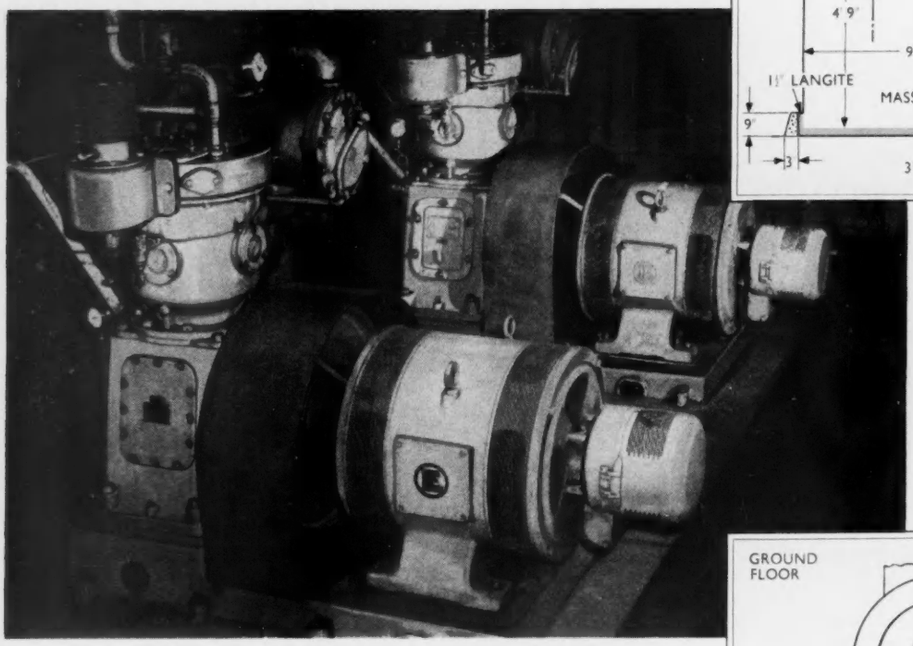
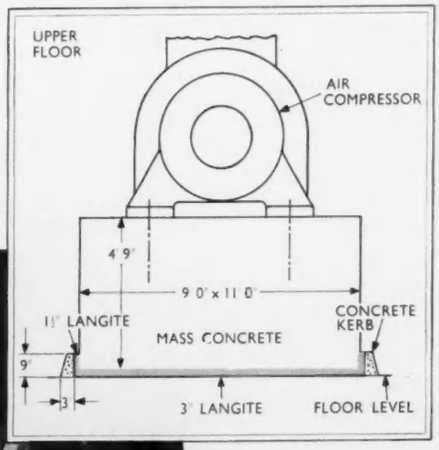
The Engineer

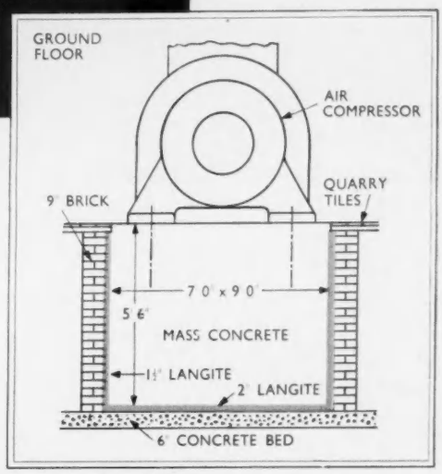
SEPTEMBER 26, 1958 28 ESSEX ST., STRAND, LONDON, W.C.2 TWO SHILLINGS

Isolating vibration with LANGITE





Two compressors are on the ground floor and one on an upper floor; the line drawings show the arrangement.



Vibration from compressors at The English Electric Company's works at Rugby has been effectively isolated from the rest of the building by the use of our resilient Langite '4V'.

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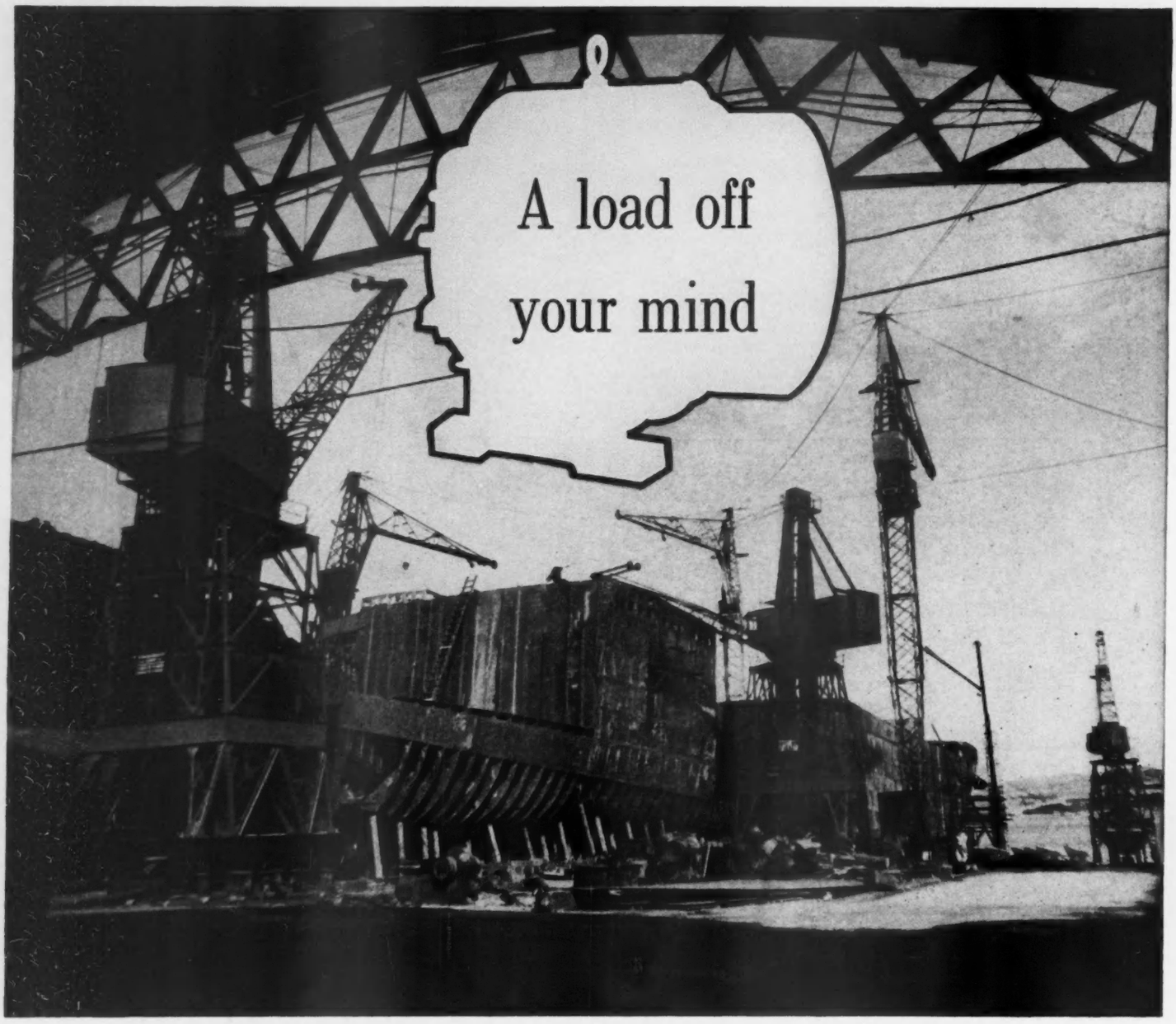

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DM 59

THE ENGINEER

Established 1856

No. 5357 **SEPTEMBER 26, 1958** **VOL. 206**

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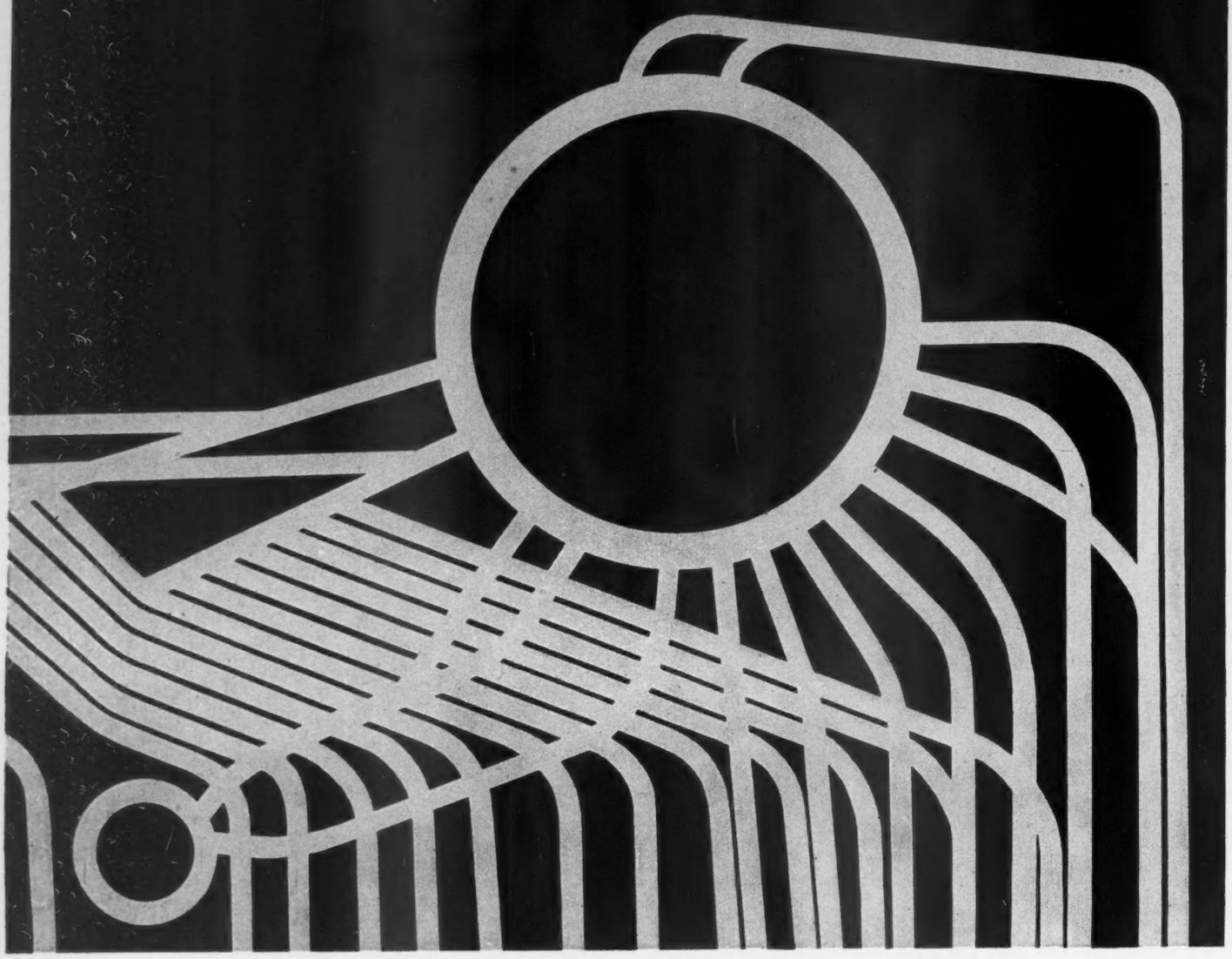
water-tube boilers



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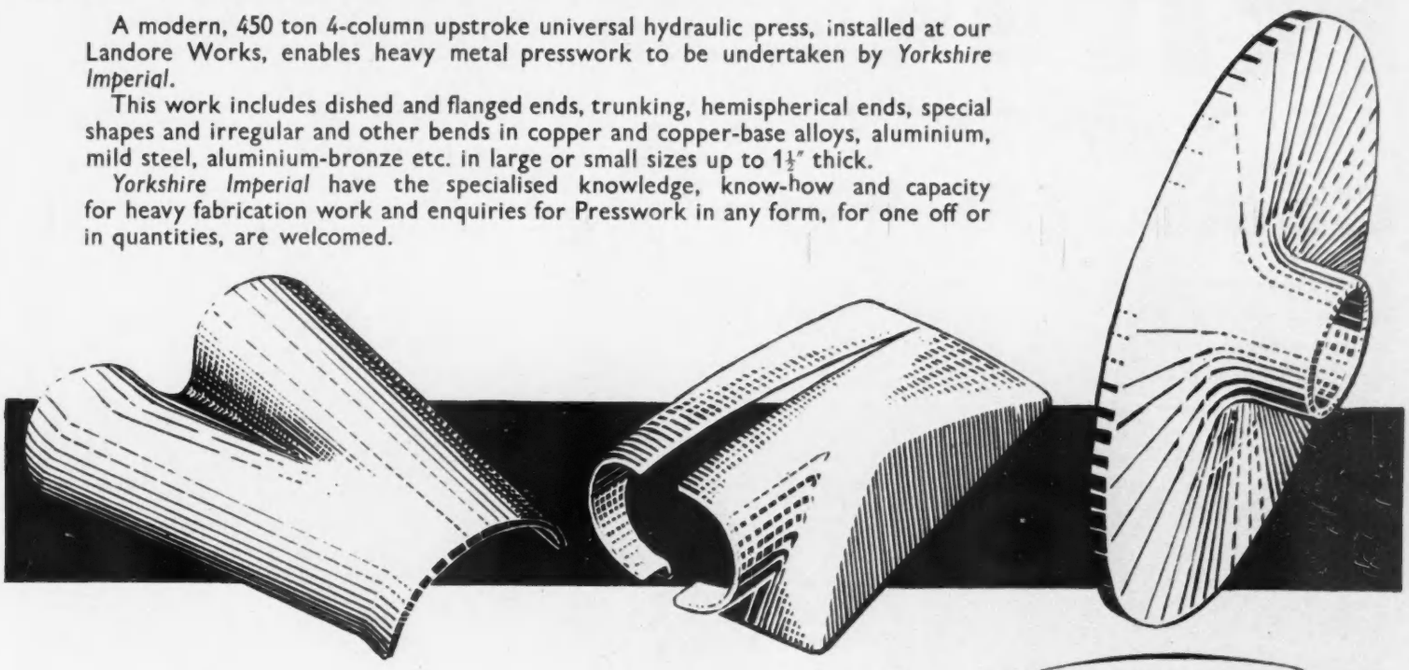

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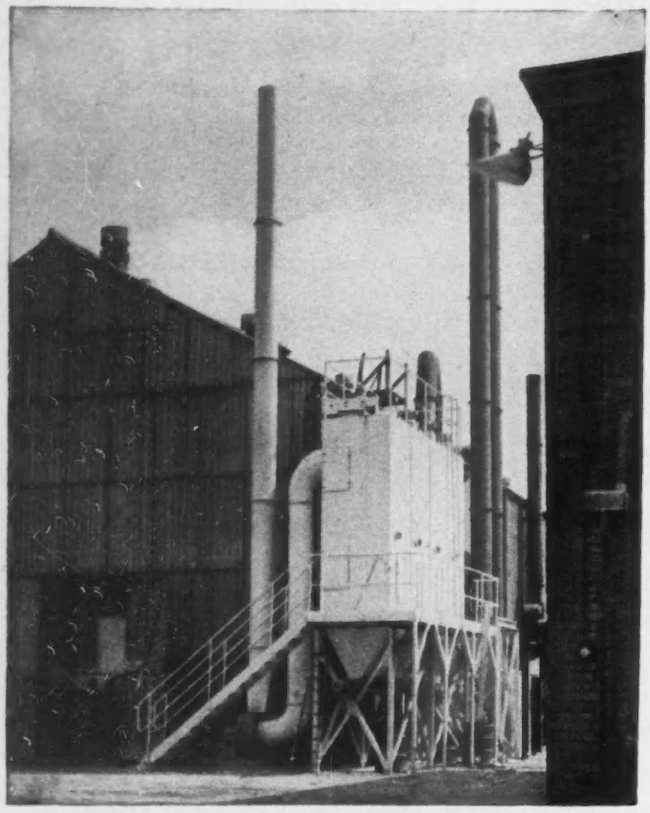

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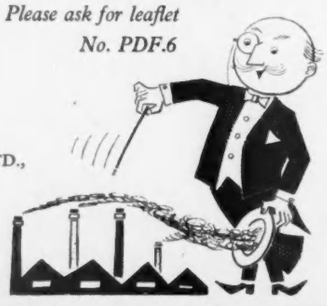

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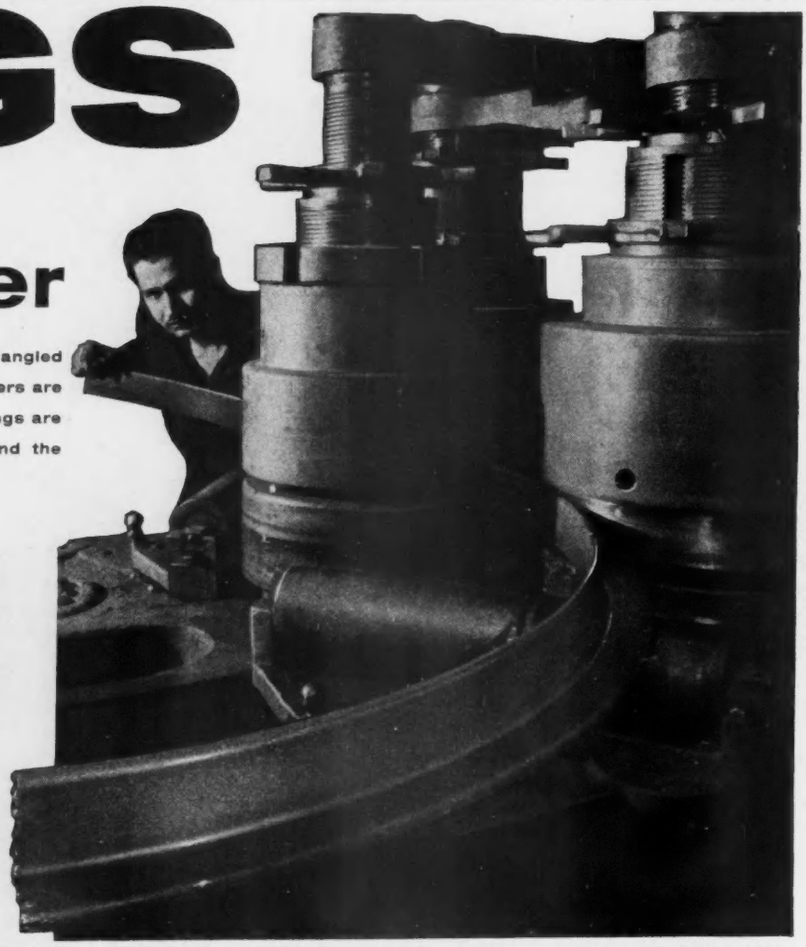

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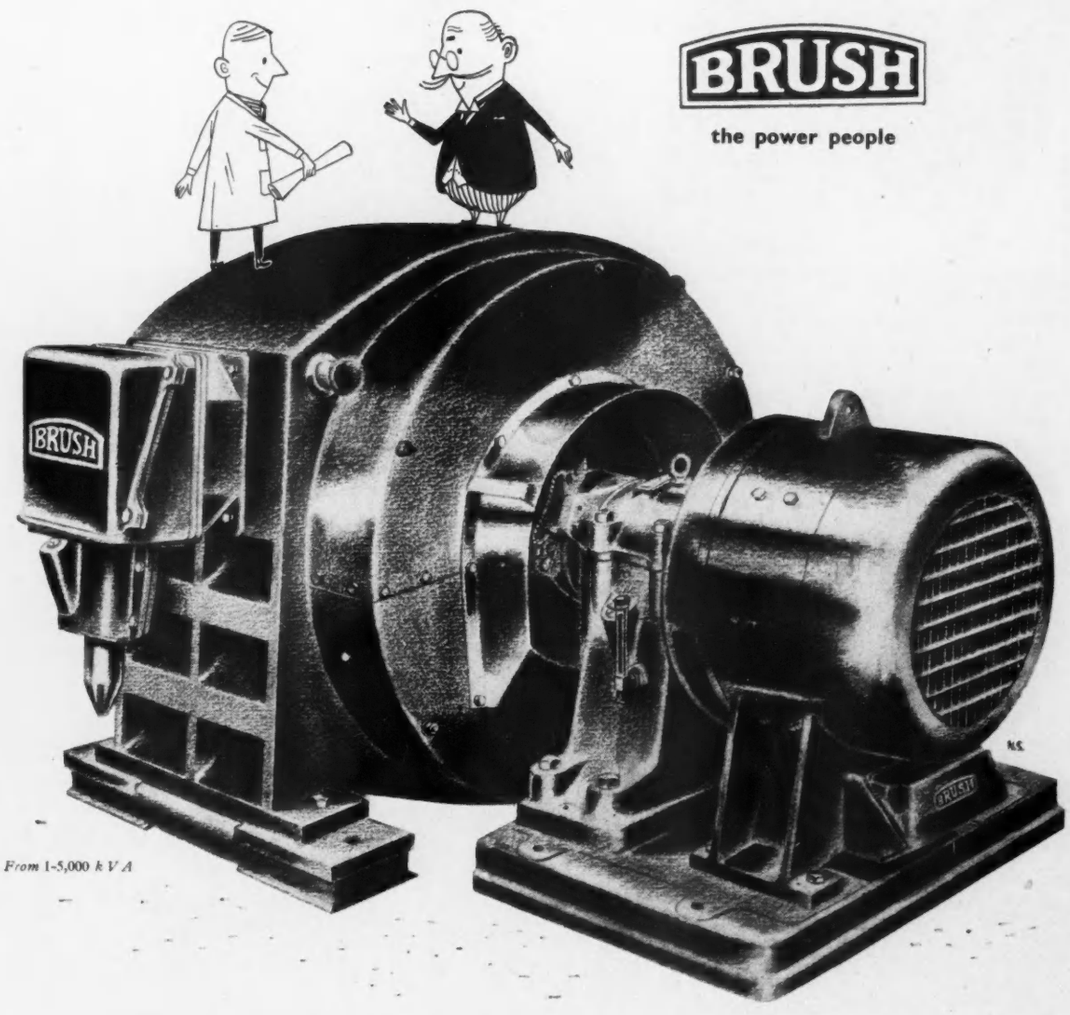

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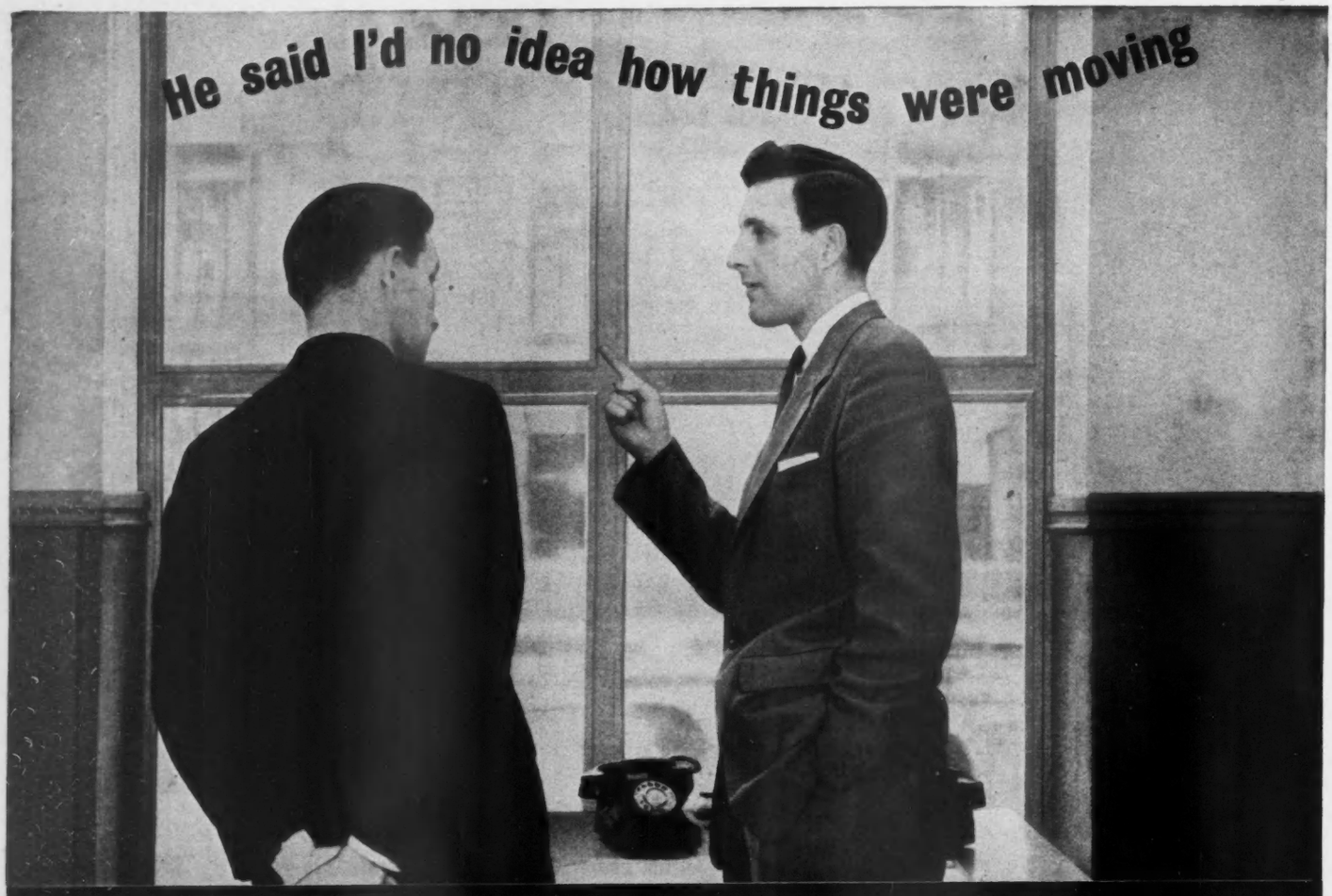

. . . and the fact is they were hardly moving at all . . . he was right . . . I'd no idea. It wasn't until I took a look around the works I realized we hadn't been moving for the last 50 years so far as materials handling was concerned! We were still paying a fantastic premium for humping things around with manpower instead of machines.

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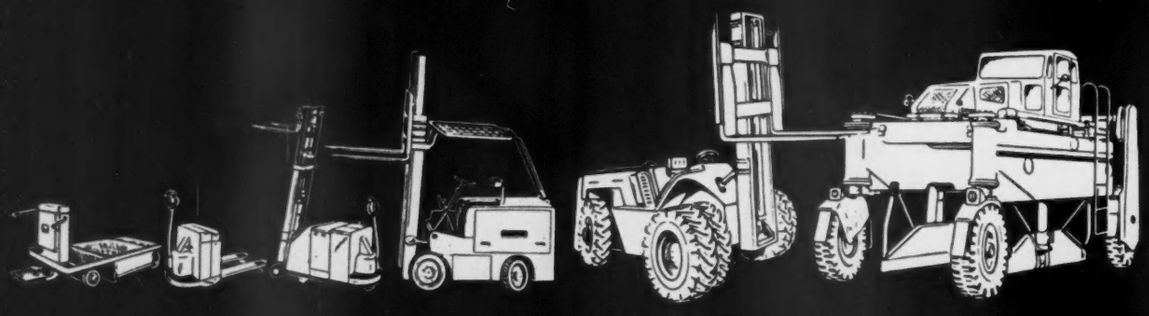

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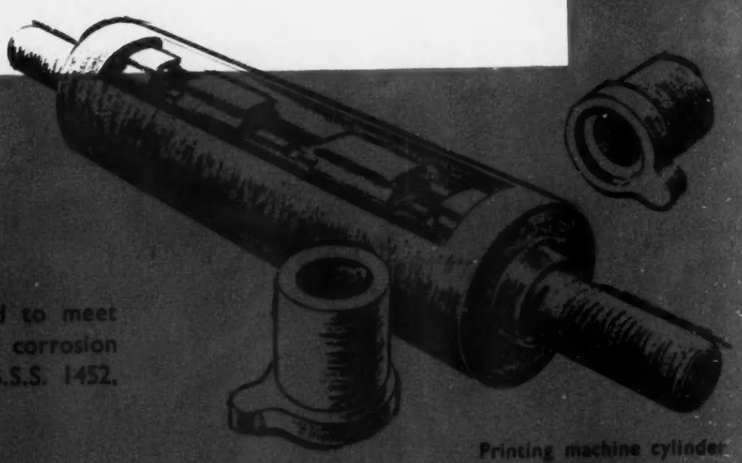

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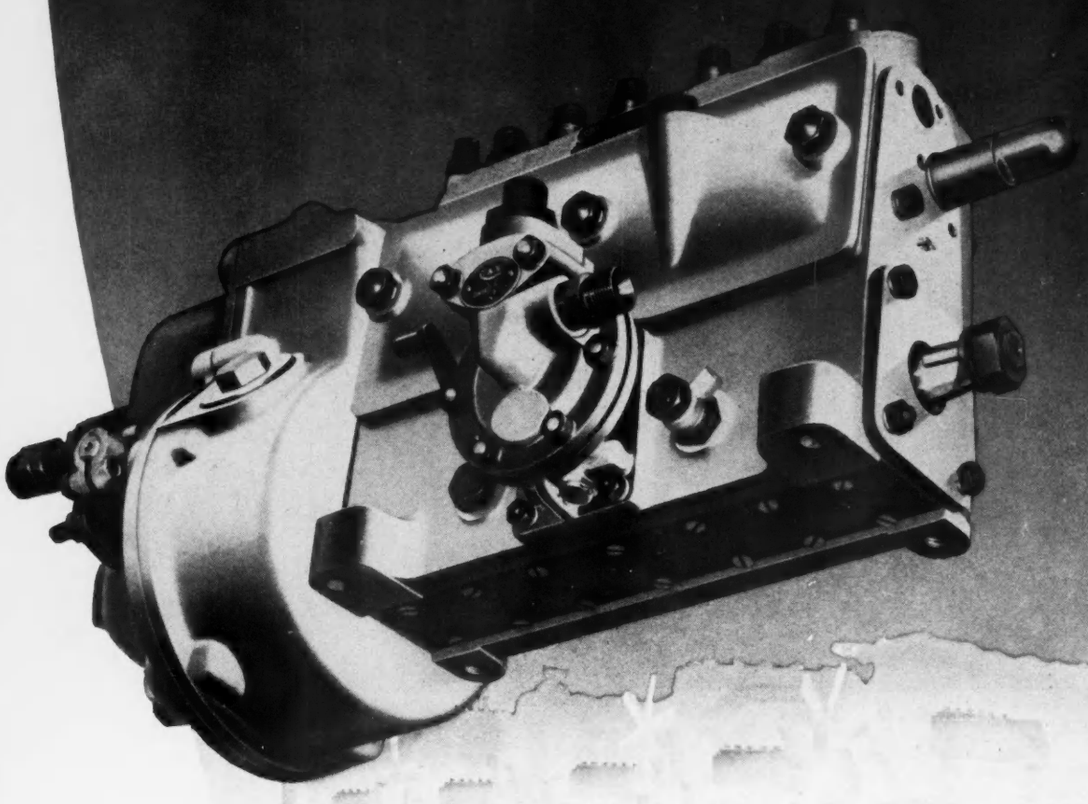

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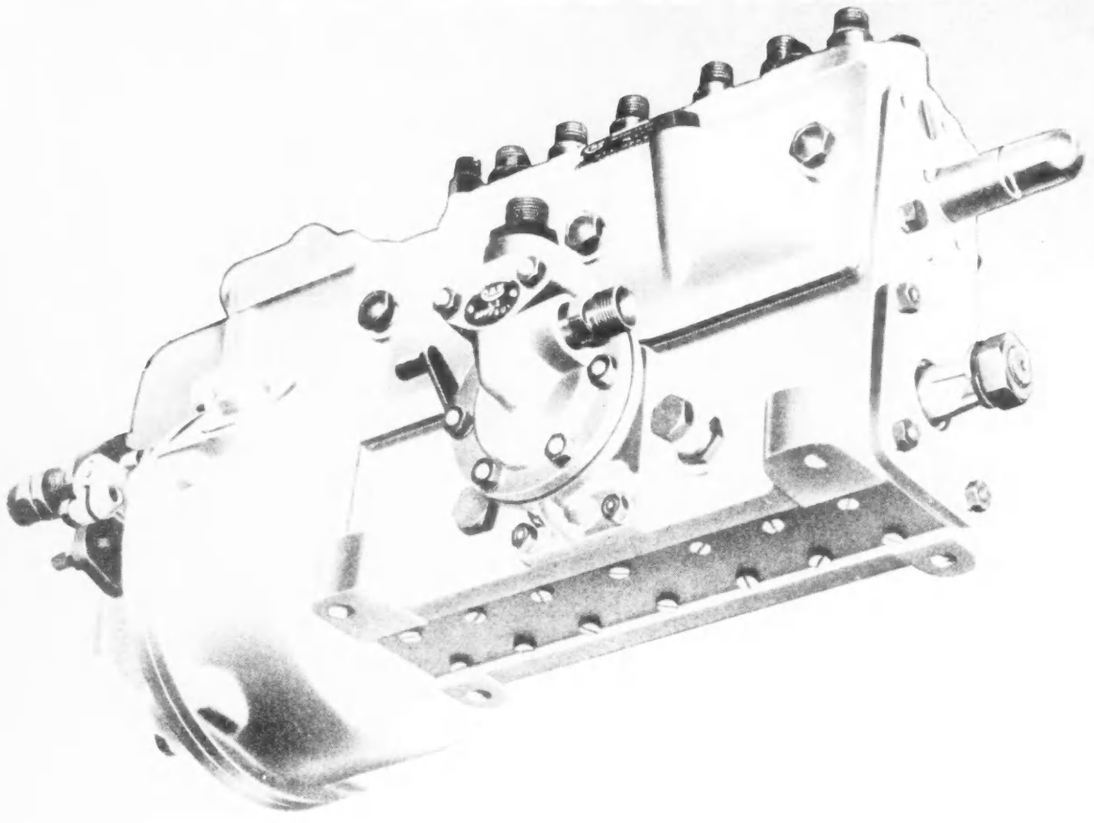

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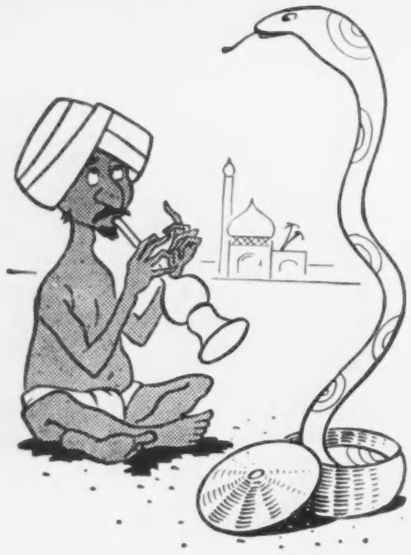

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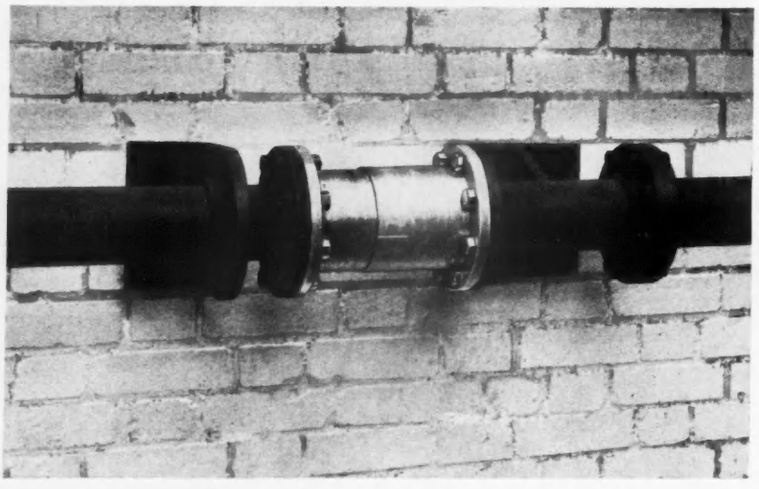

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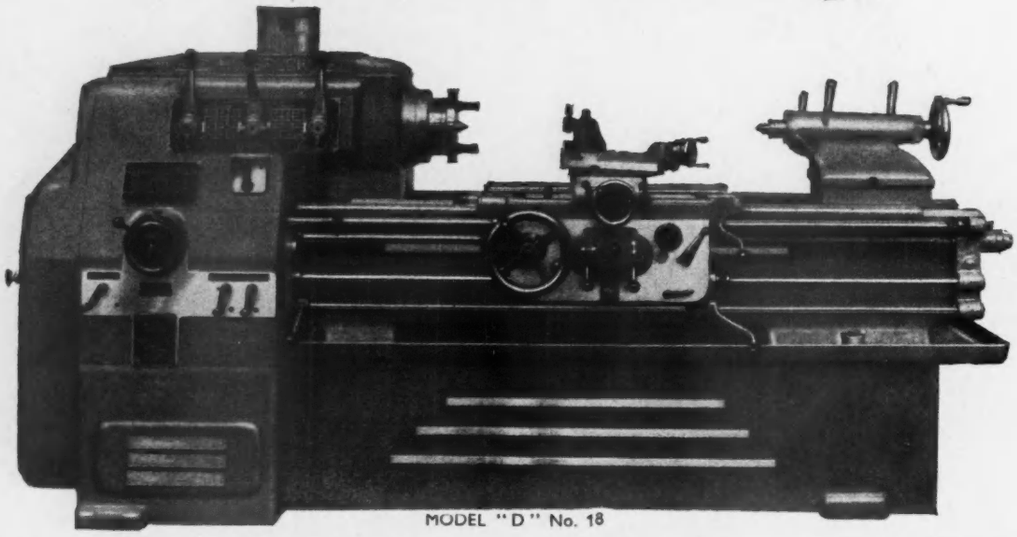

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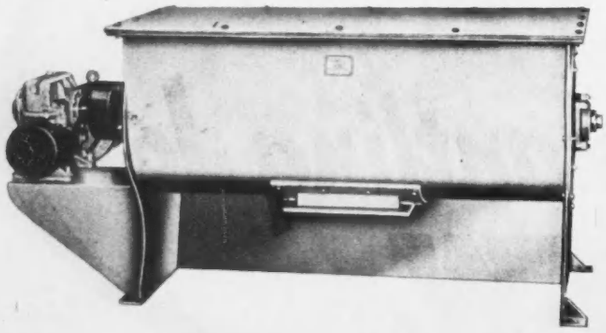

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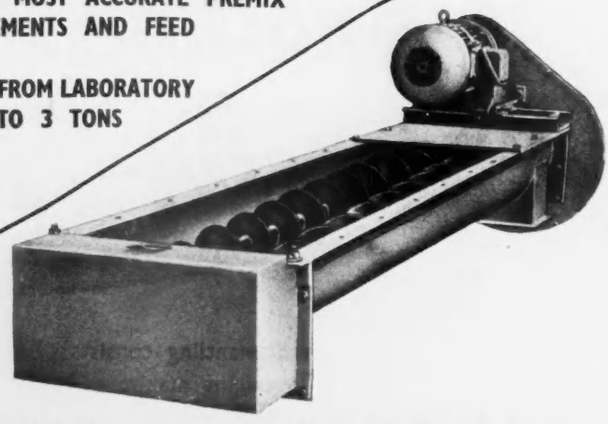

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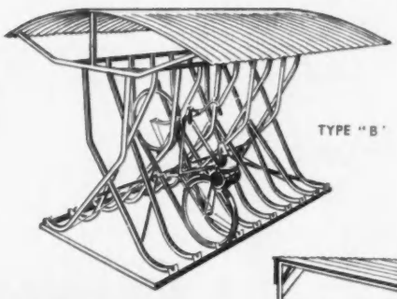

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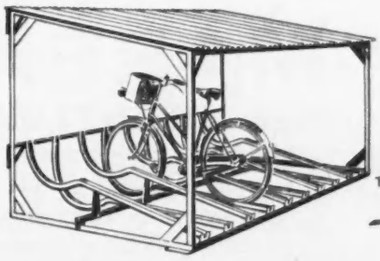

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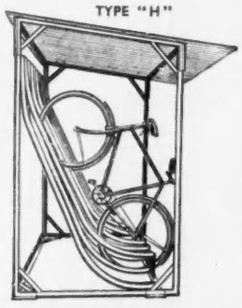

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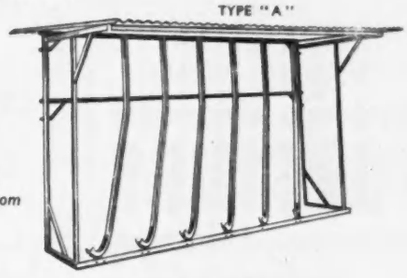

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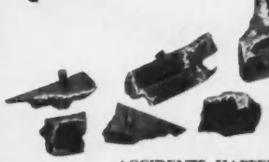
Badly damaged Auxiliary diesel engine casting. There were also serious extensive cracks; they cannot be seen in this picture.



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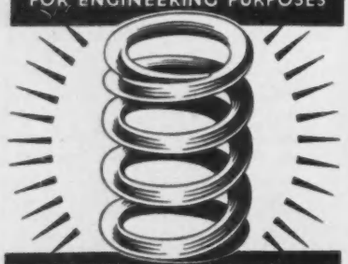

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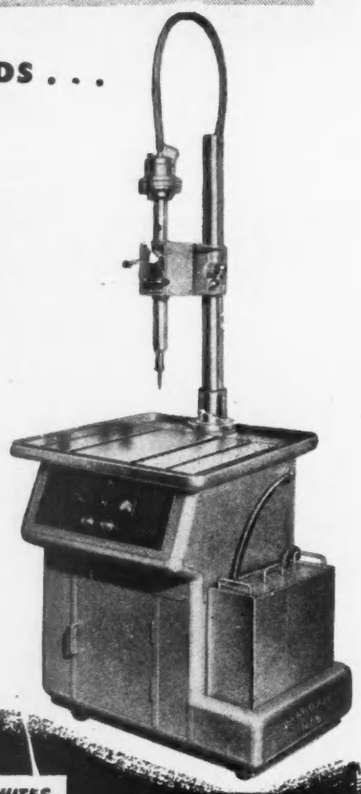

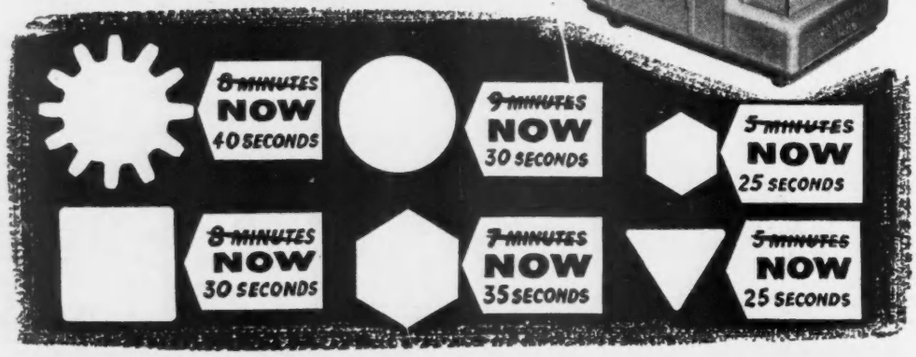
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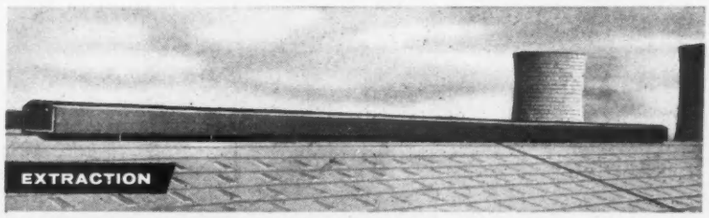

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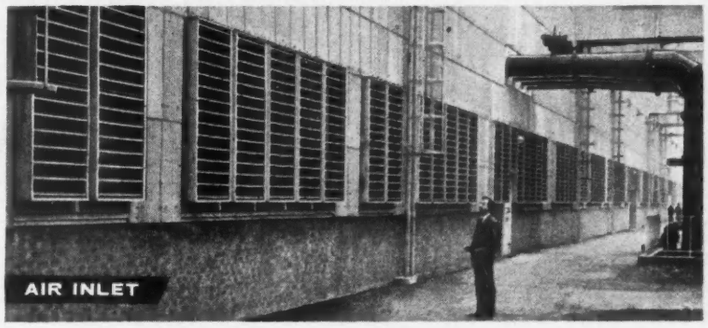

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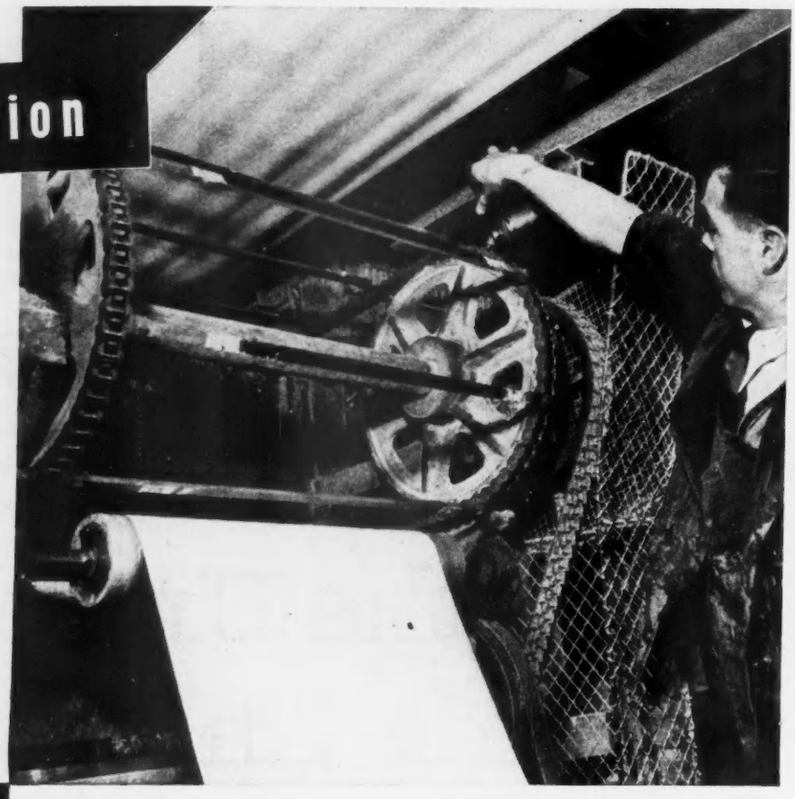

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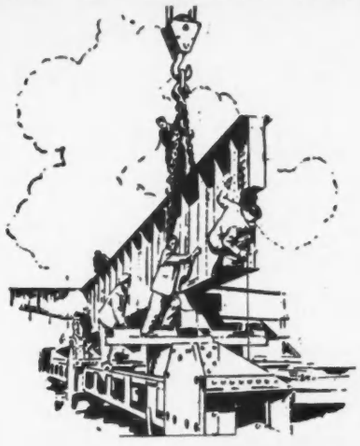

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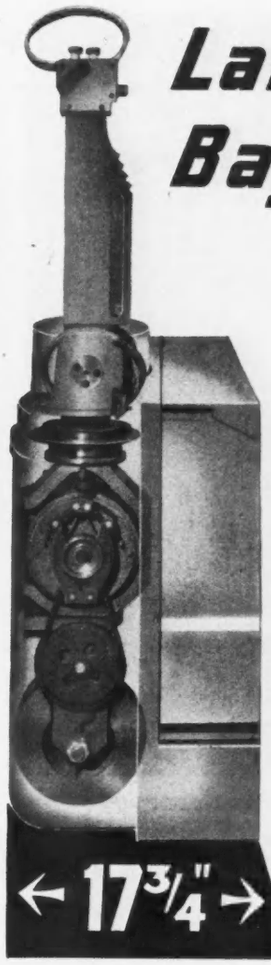

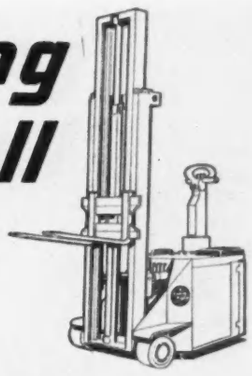

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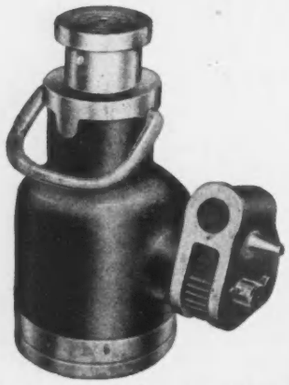

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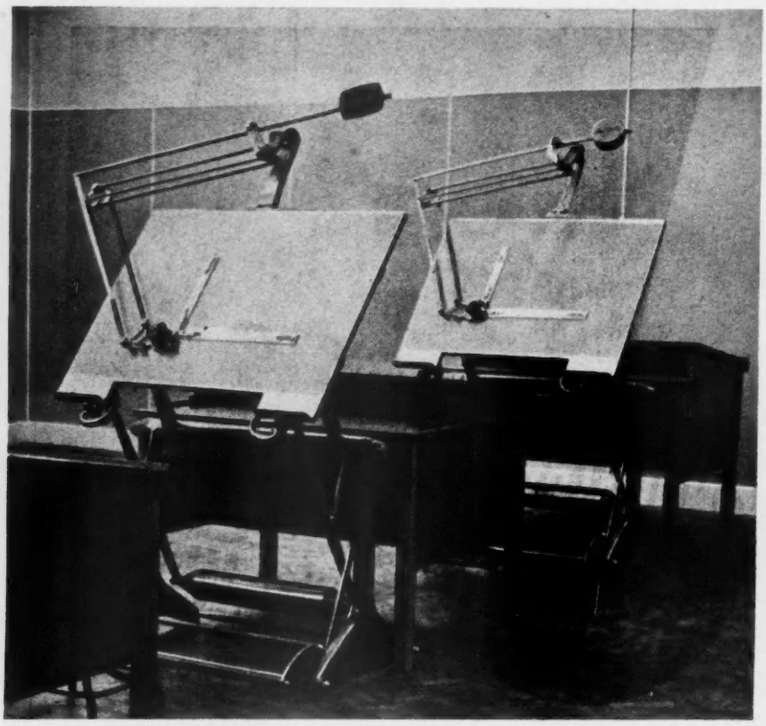

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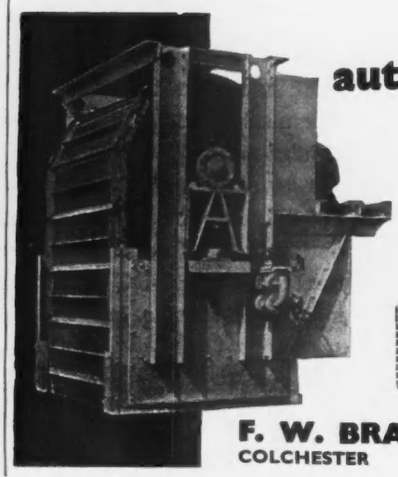

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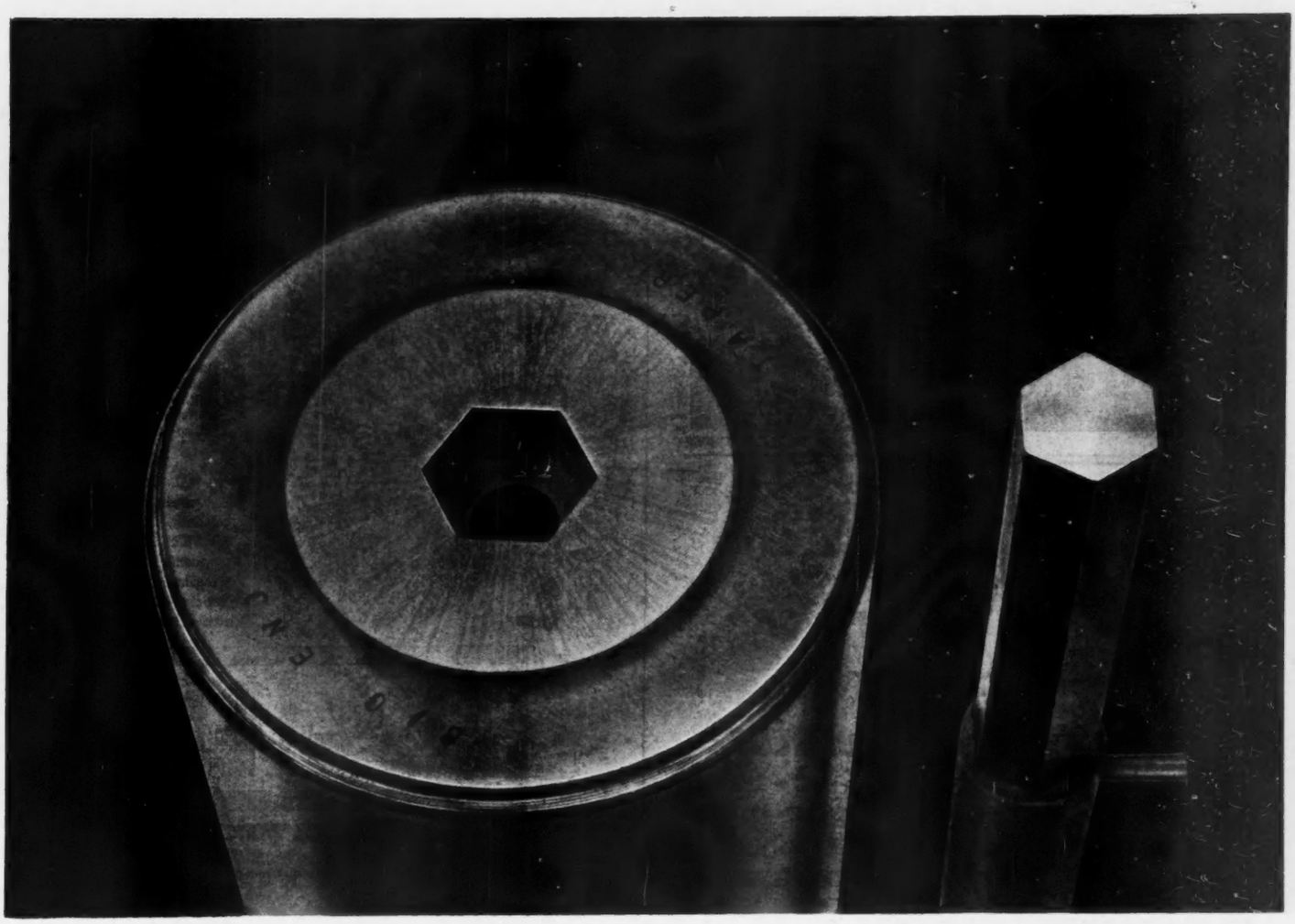

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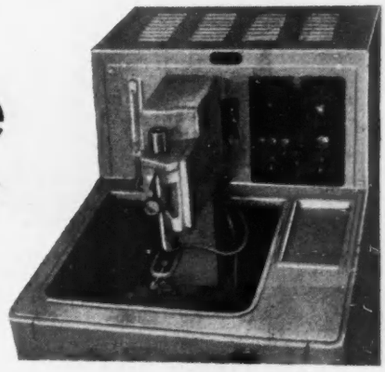

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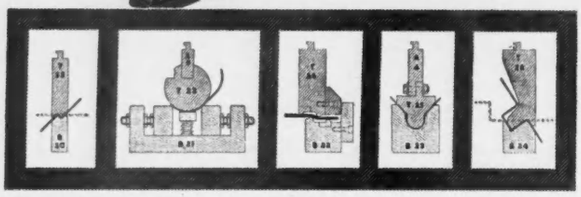

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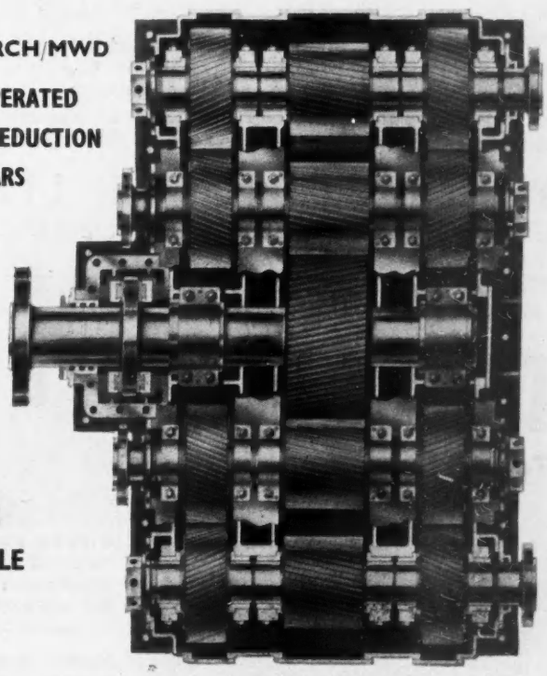

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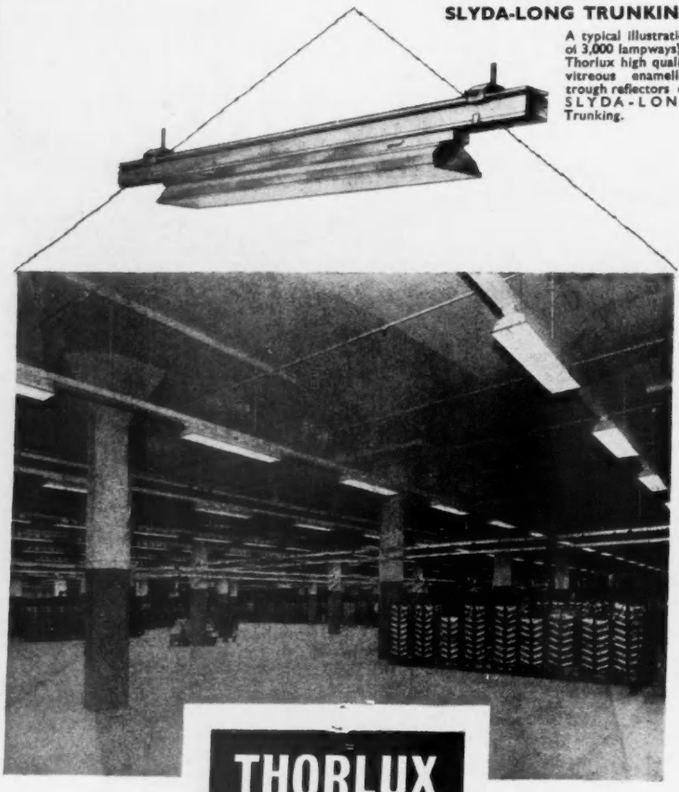

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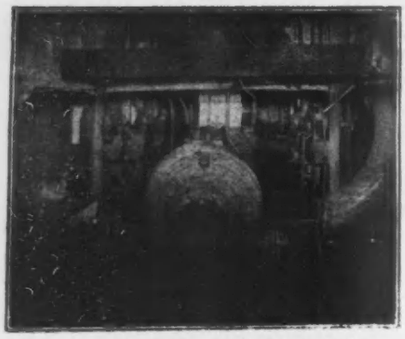

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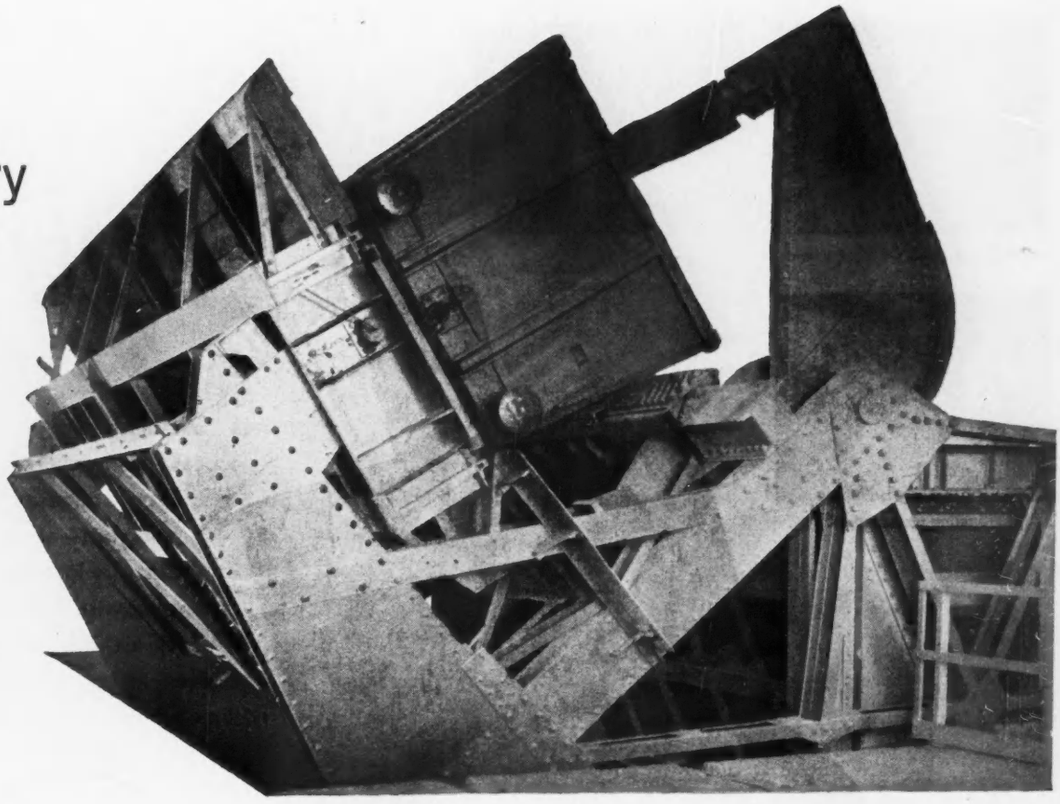

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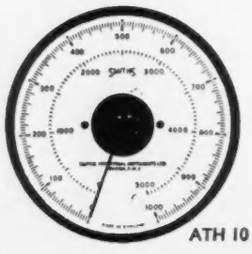

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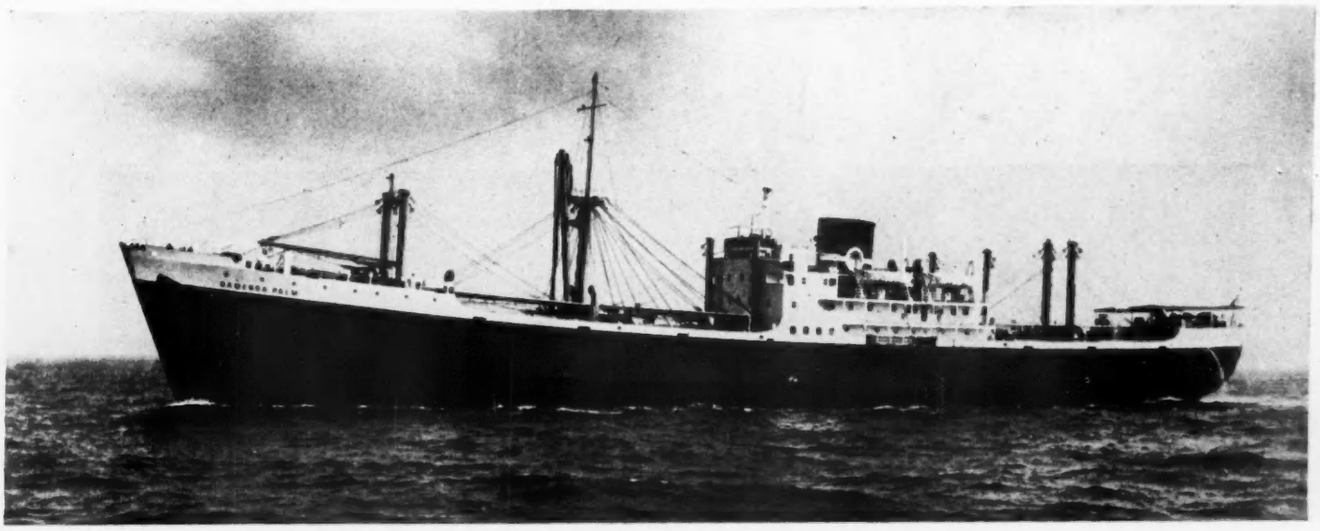

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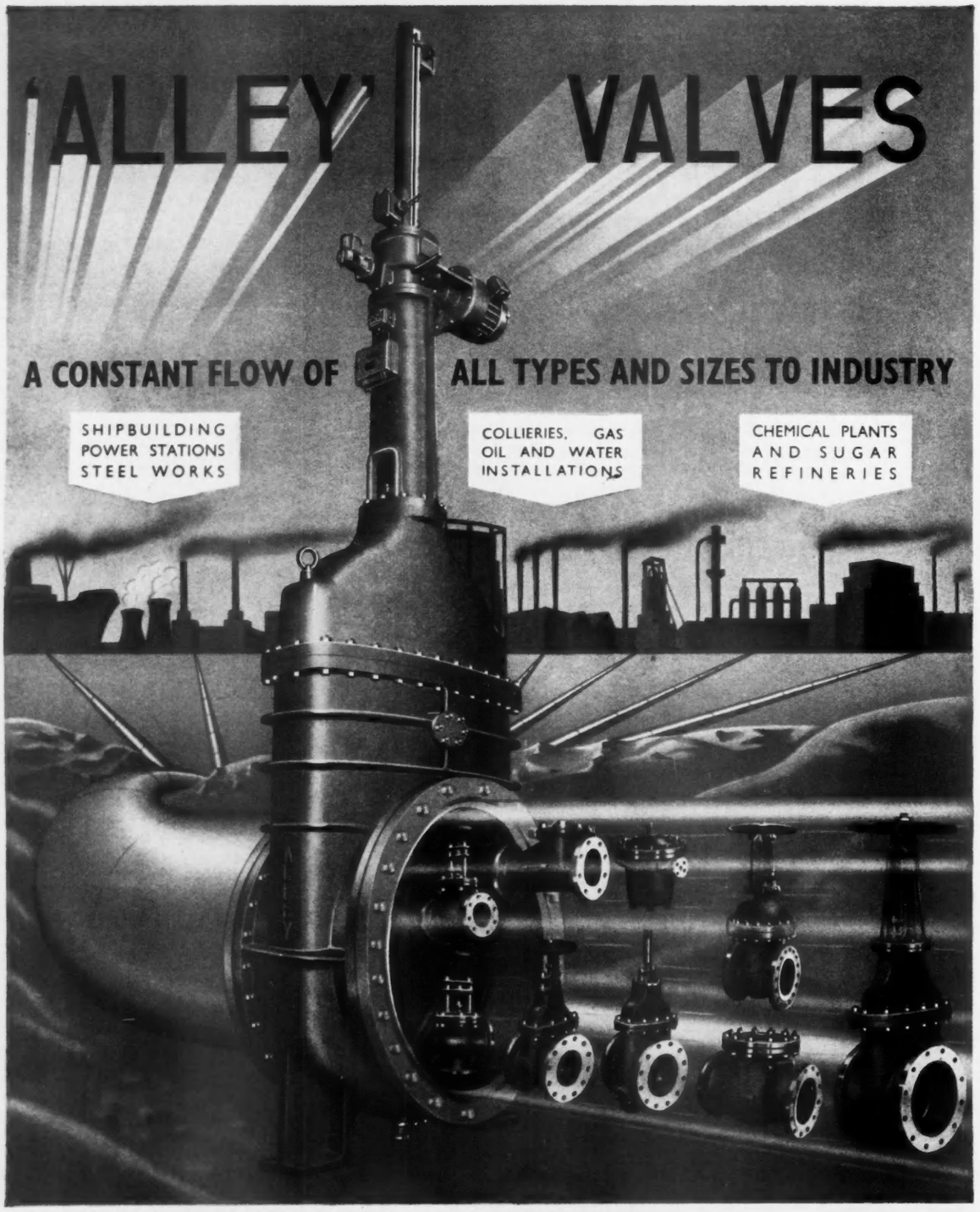

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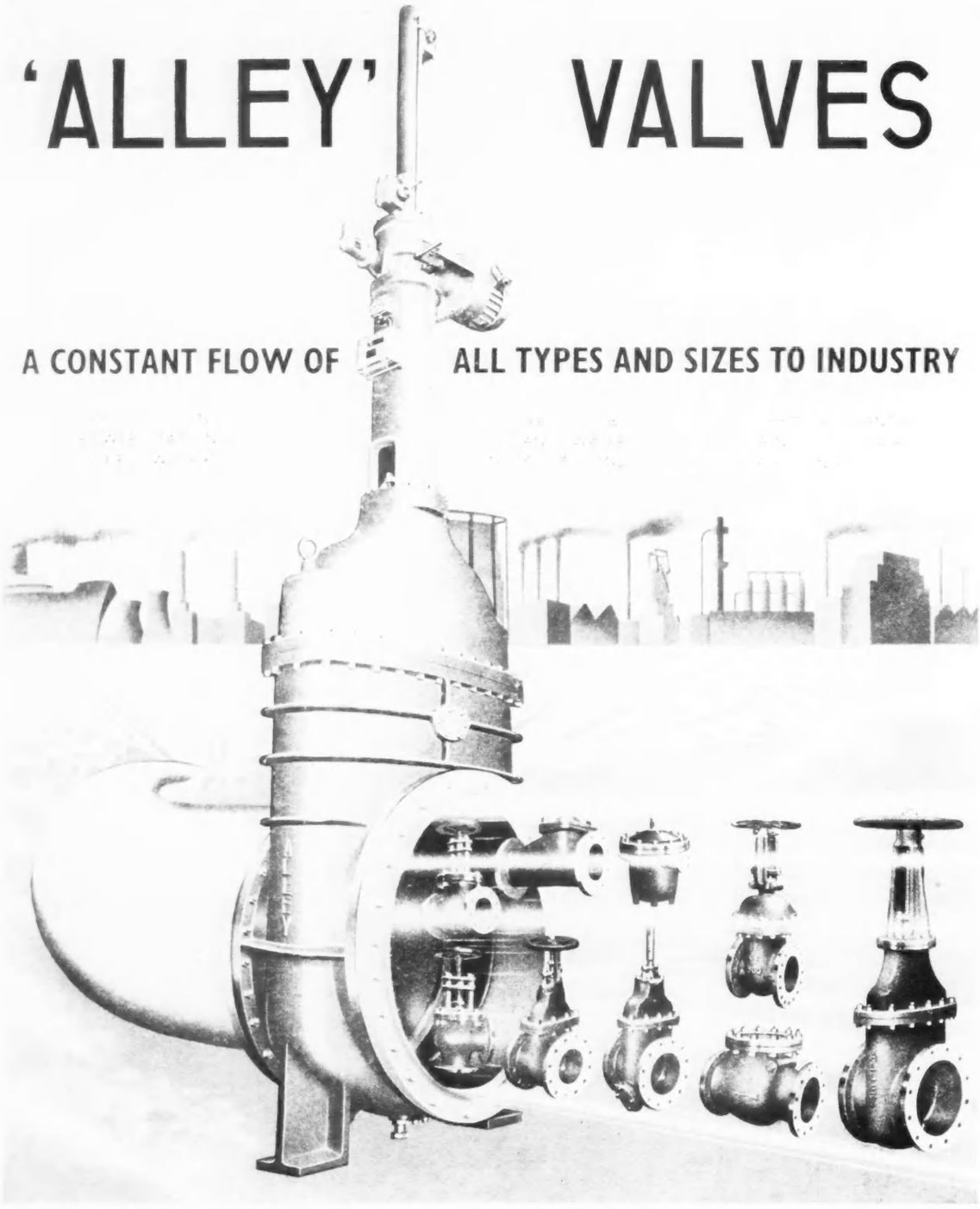

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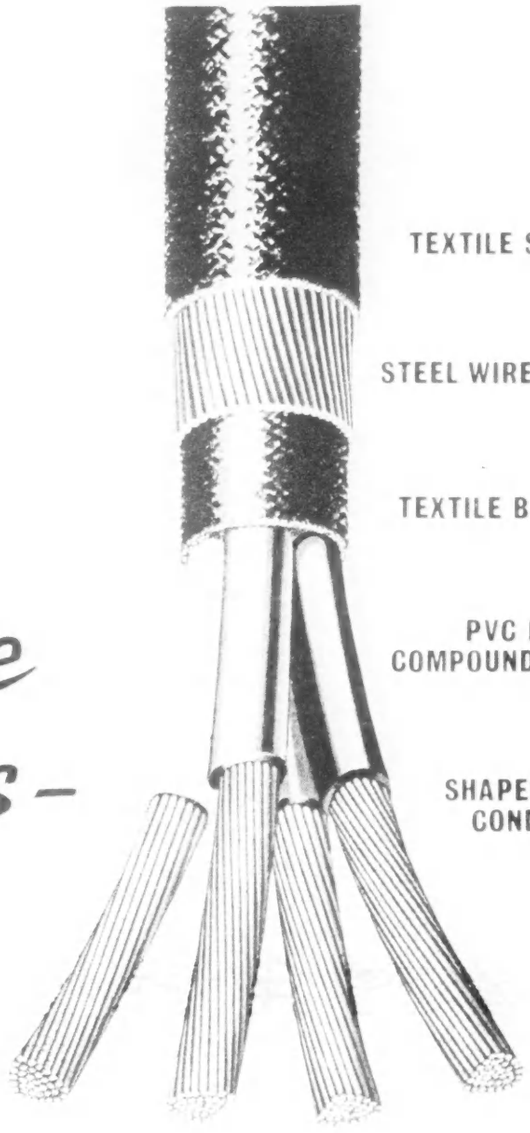

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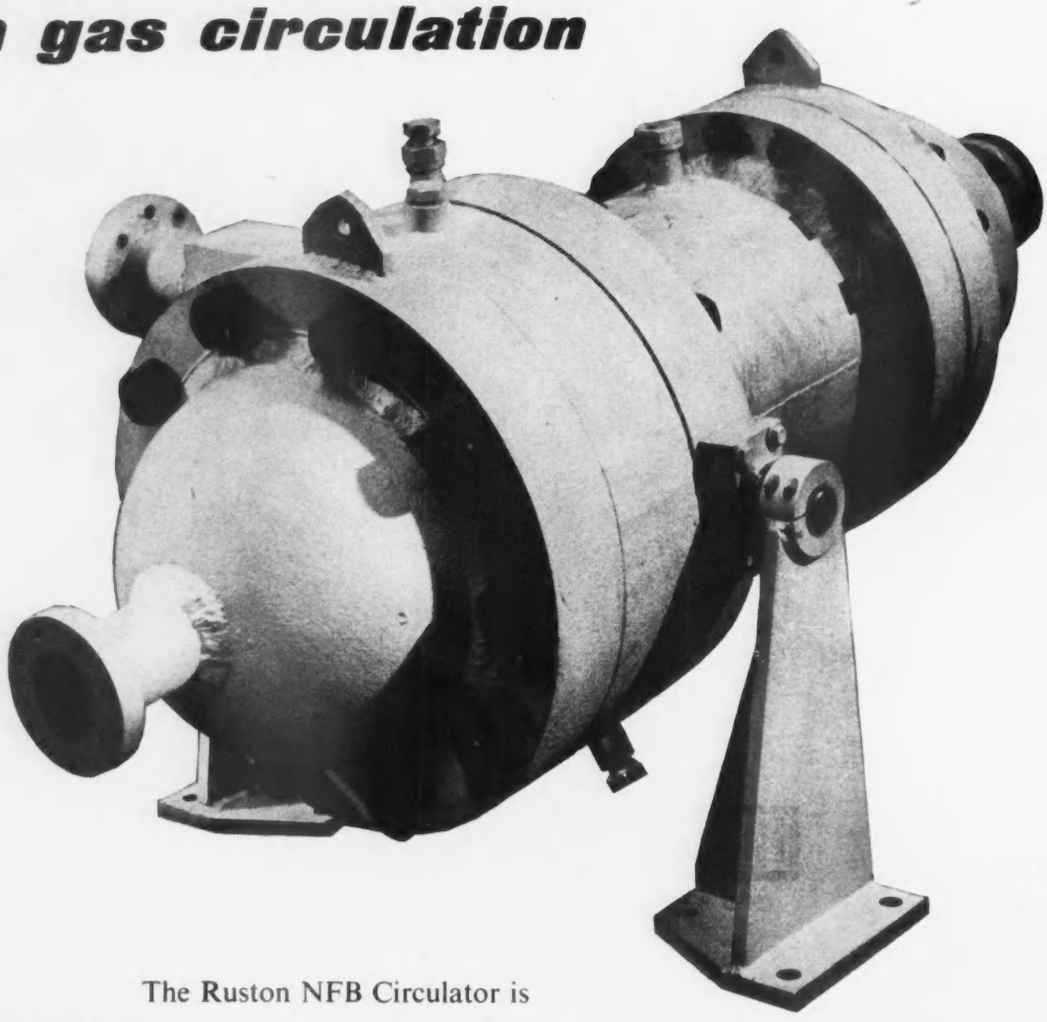

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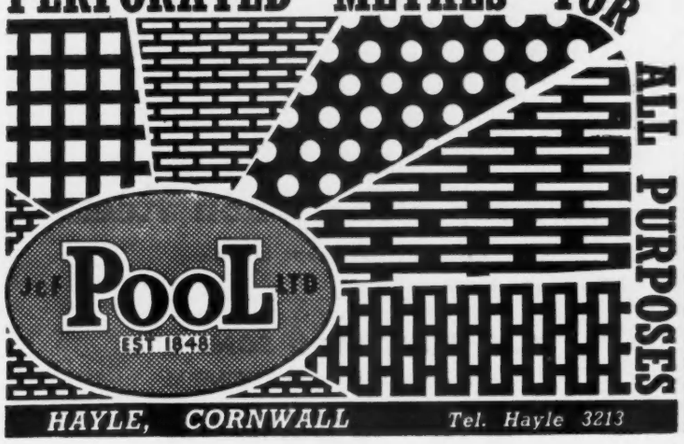

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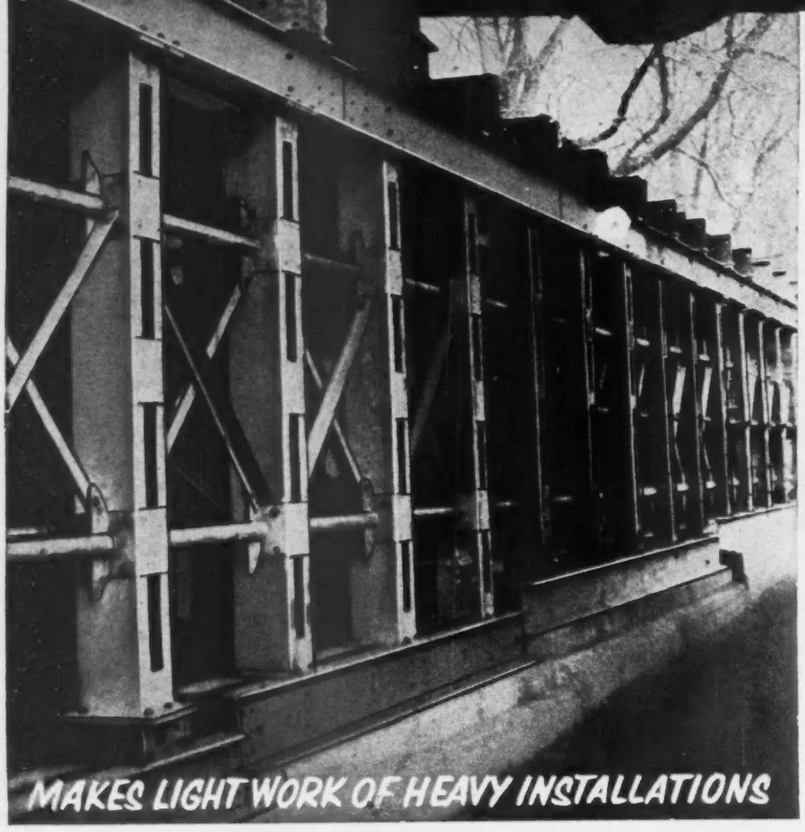

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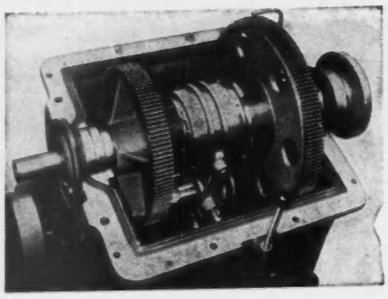

The illustrations show a typical application. The Reid Gear Co., Ltd., required a powerful, sensitive and completely trustworthy clutch unit for their two-speed reduction gear, to transmit the enormous effort applied in actuating the emergency sluice gate on a Scottish Hydro-Electric Project. The features mentioned above qualify Taylor Clutches to satisfy such exacting demands because they constitute the very ingredients of strength and reliability—the choice was a Taylor Multiple Disc Clutch.

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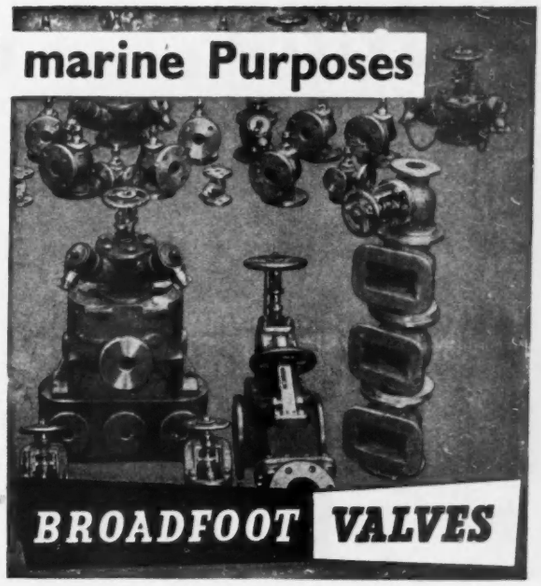

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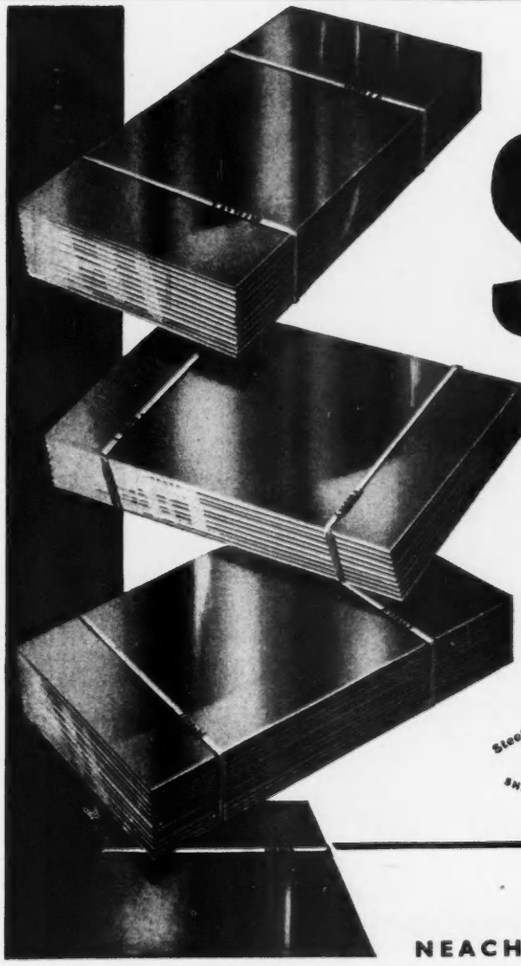

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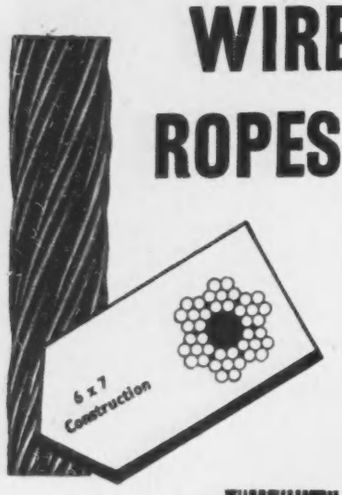

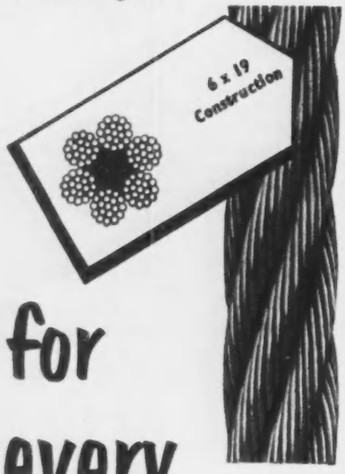

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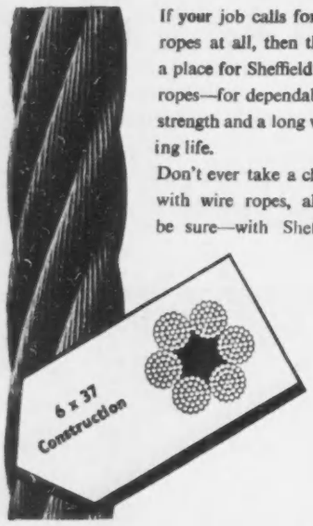

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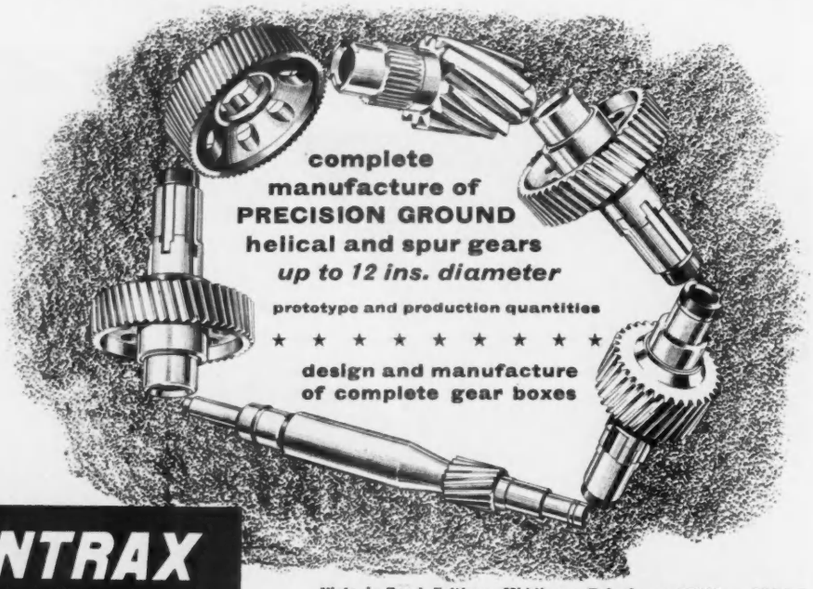

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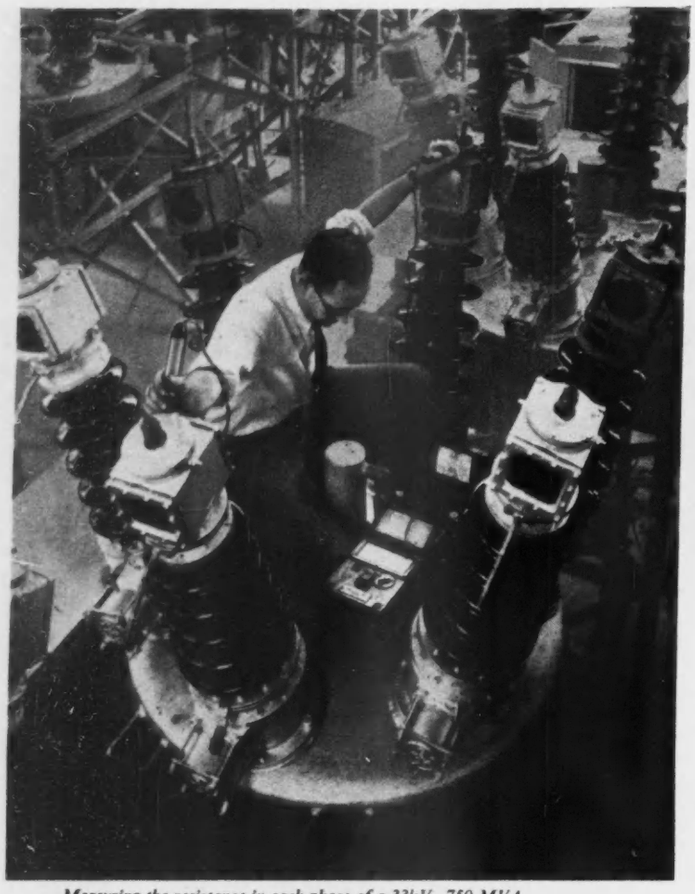

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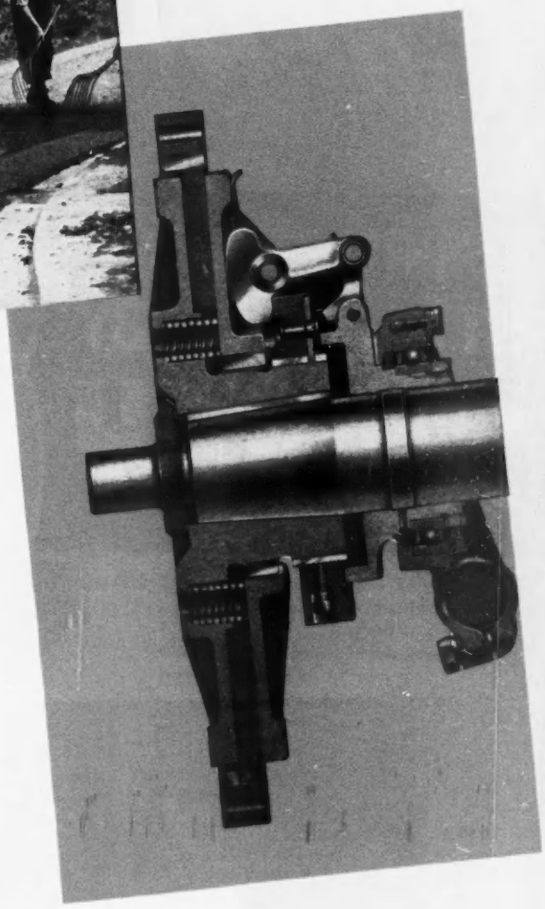

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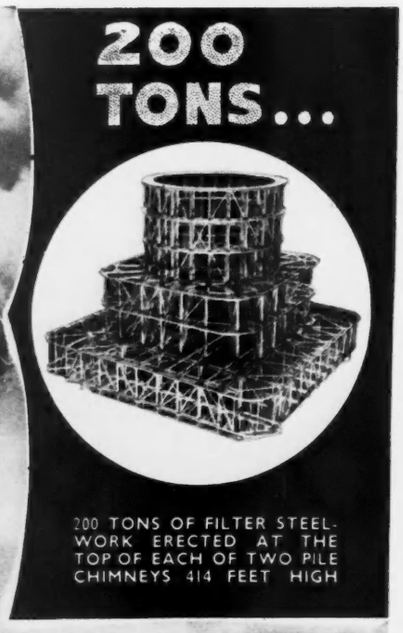

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Photograph of one of the Pile Buildings & Blower Houses at Windscale Works, Sellafield, Cumberland.
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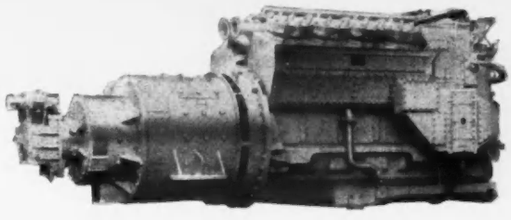

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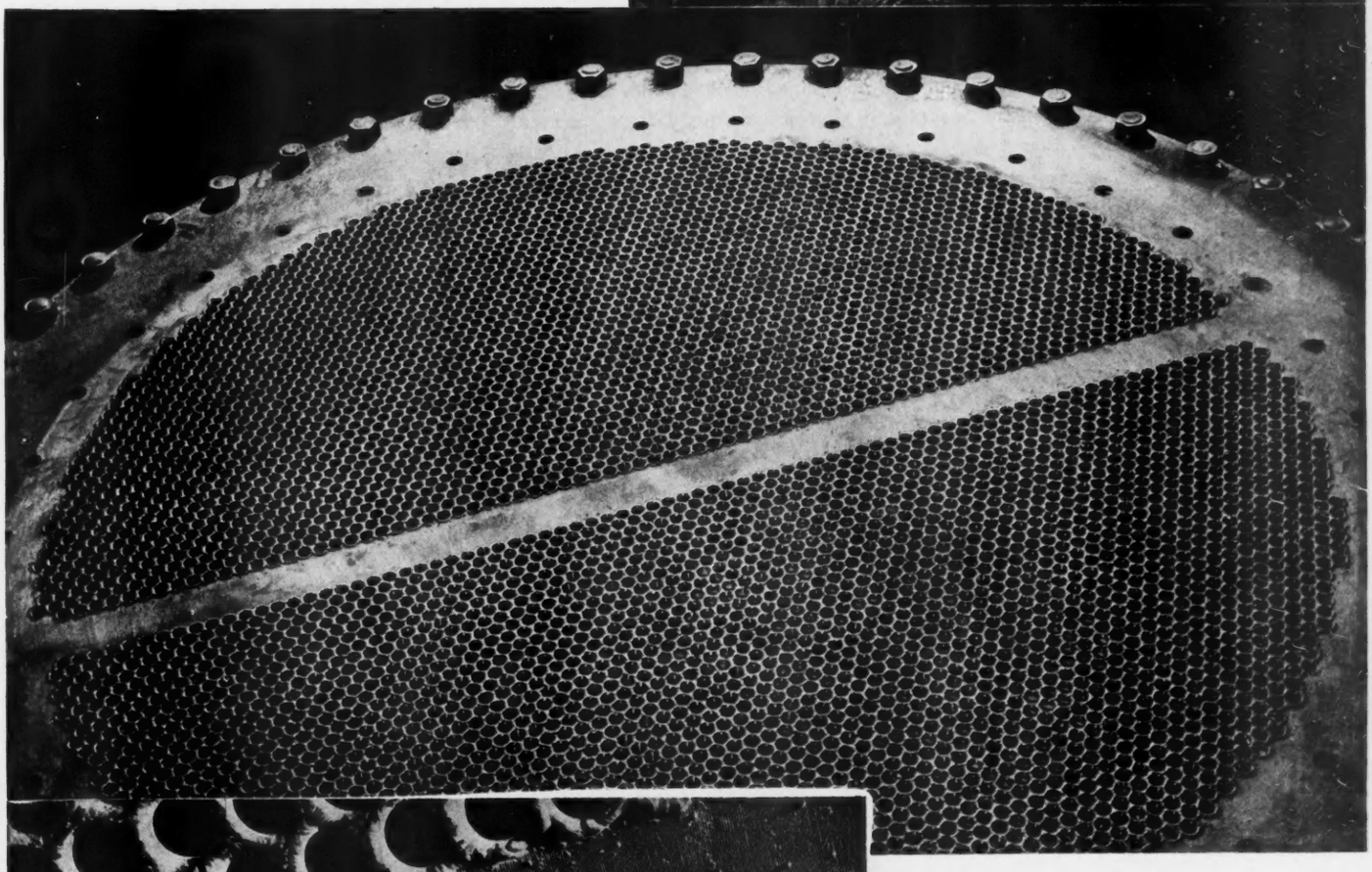

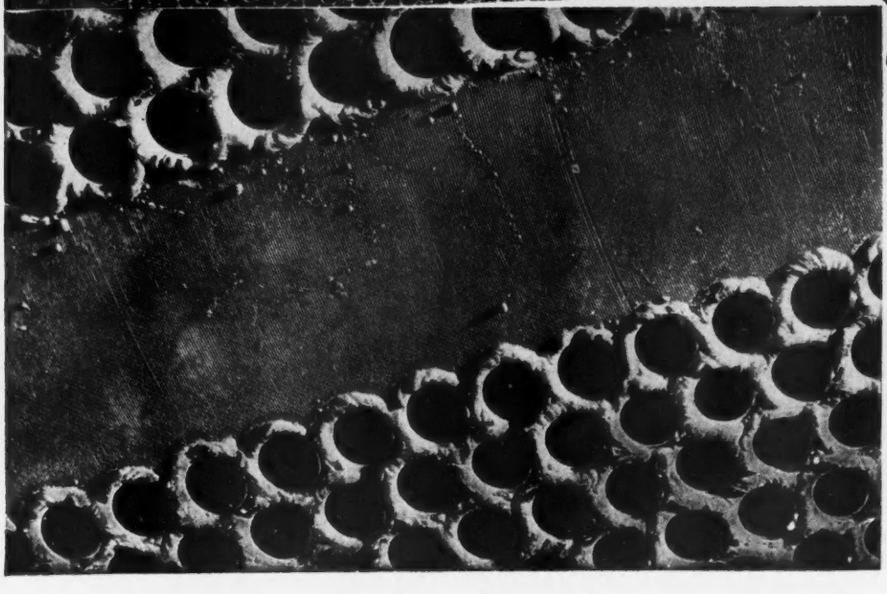

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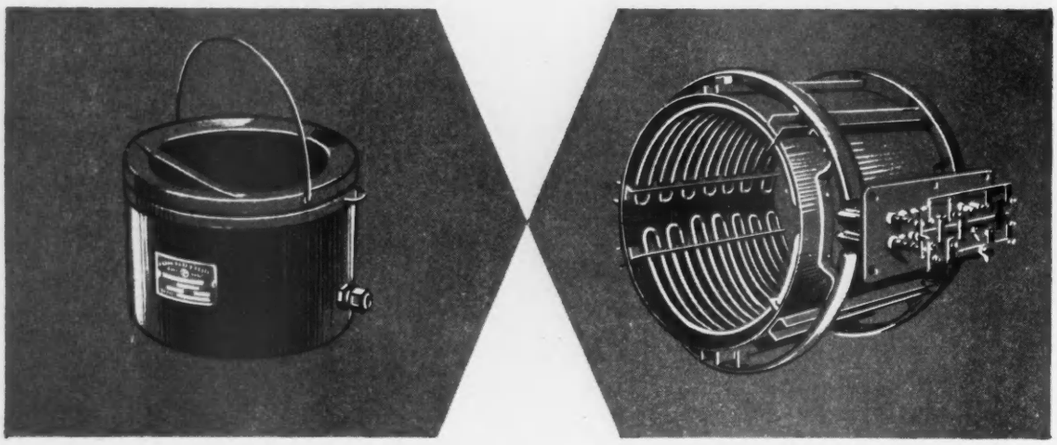

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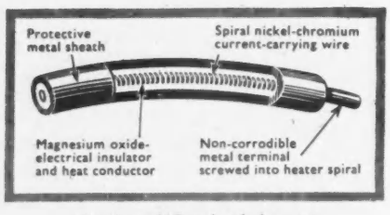
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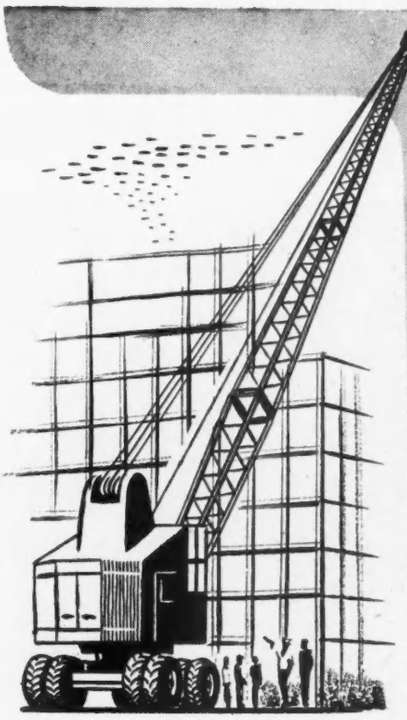

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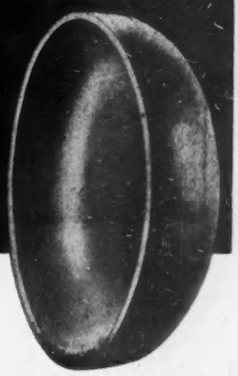

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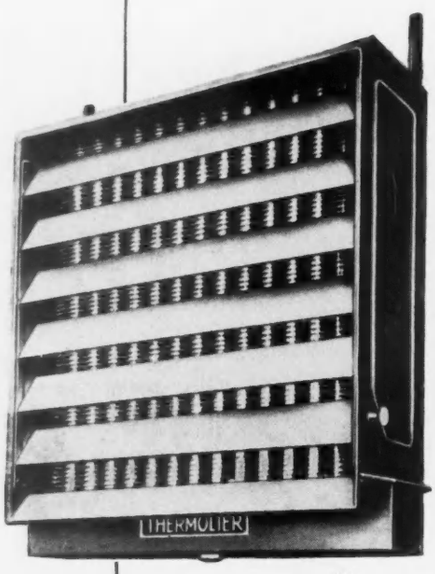

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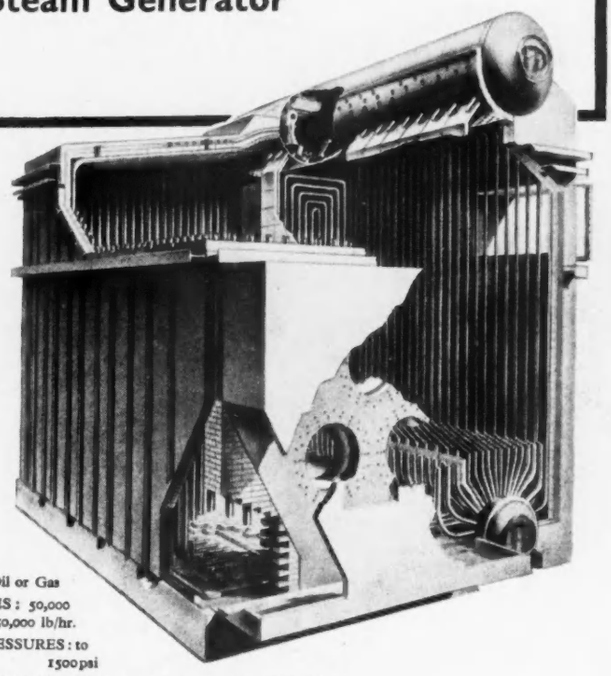

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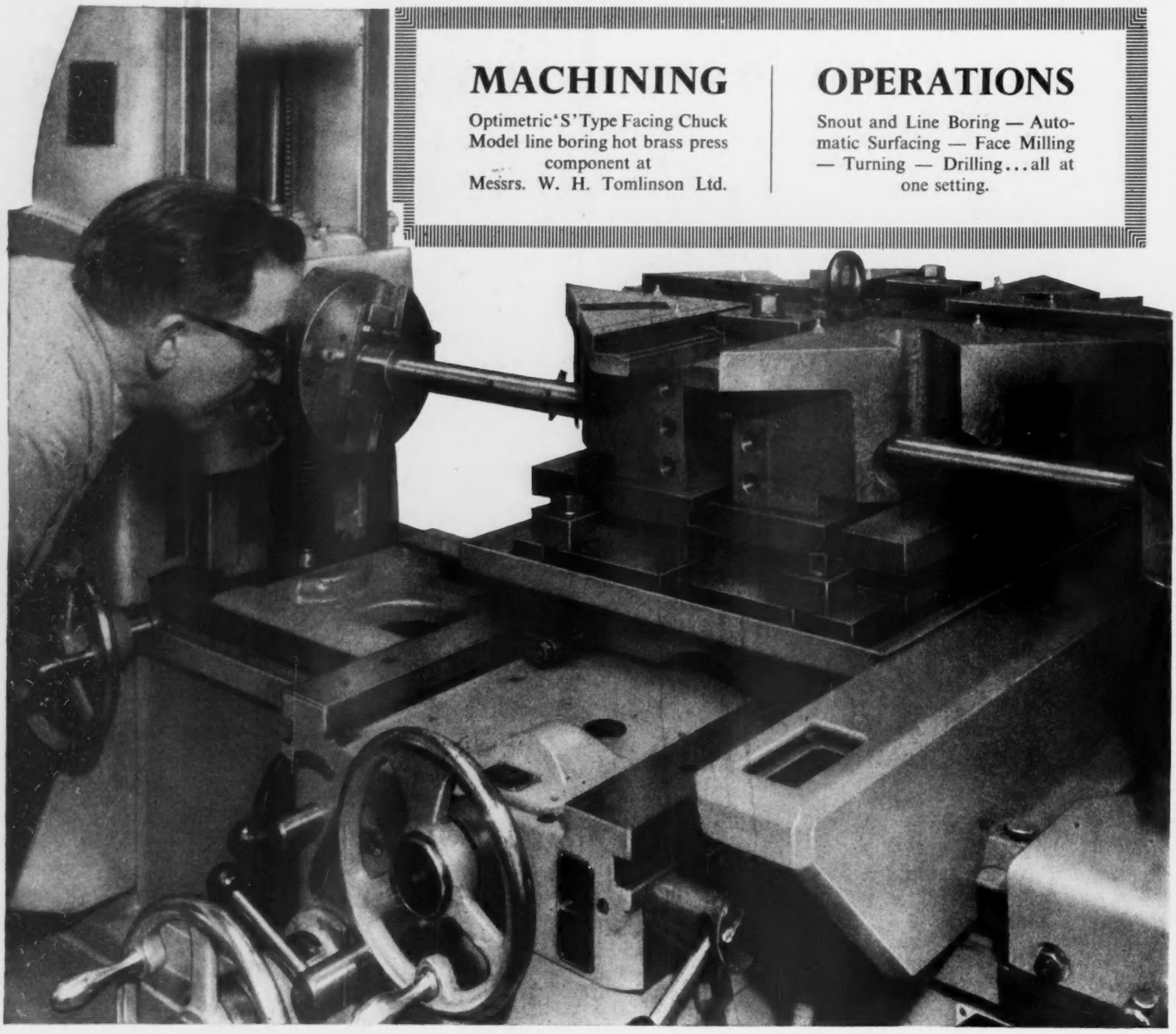

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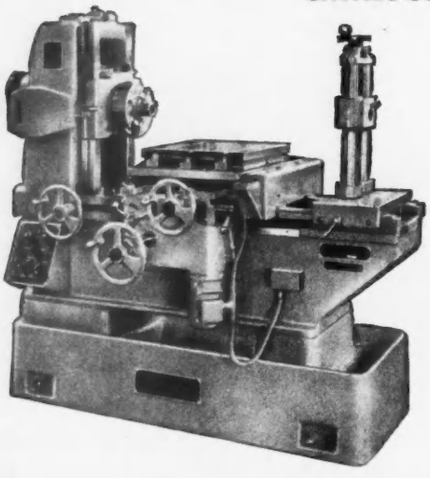

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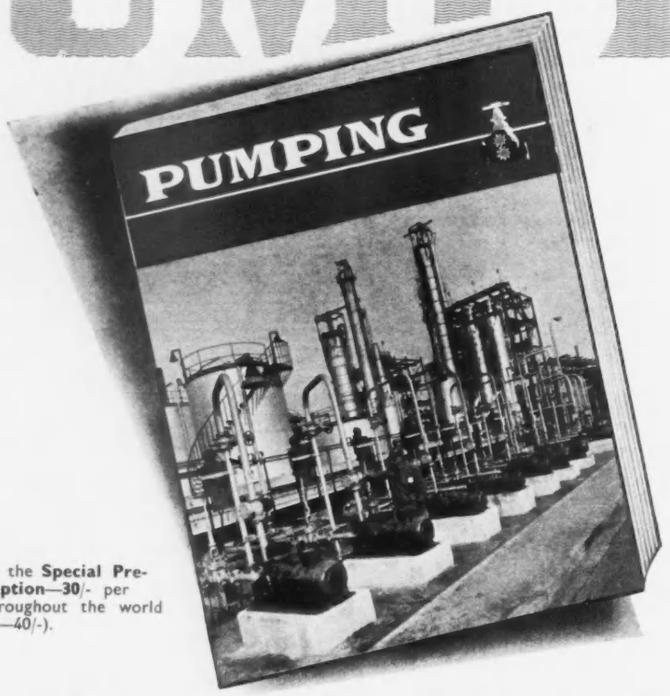

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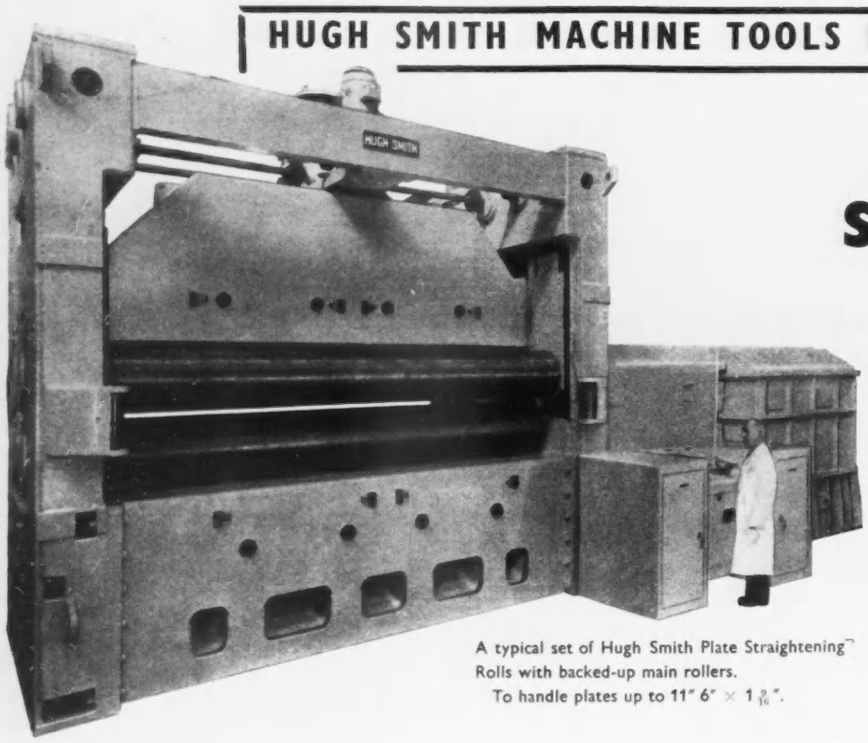

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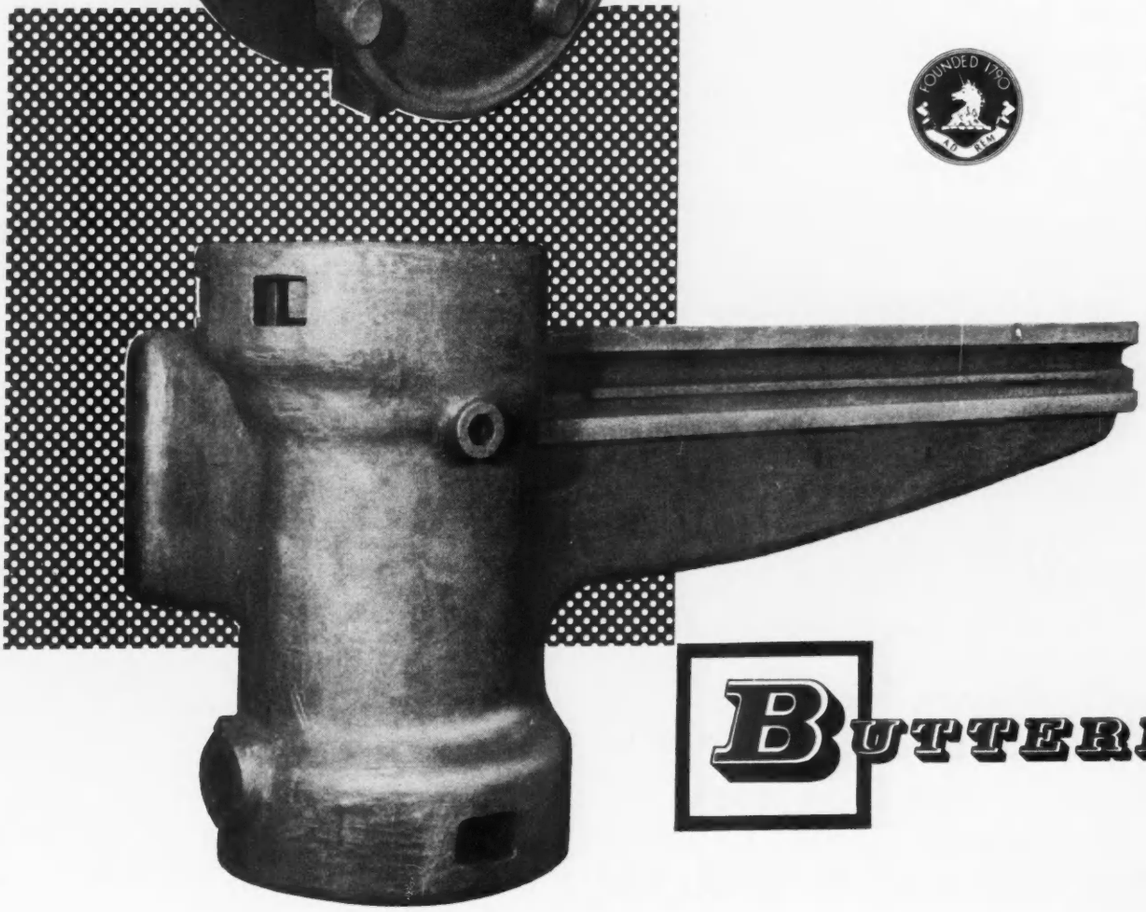

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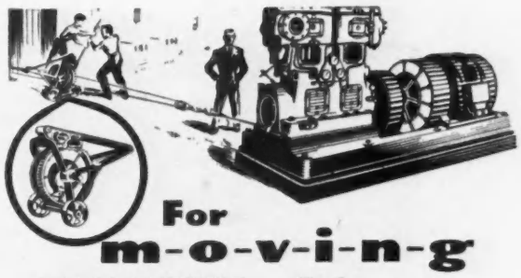

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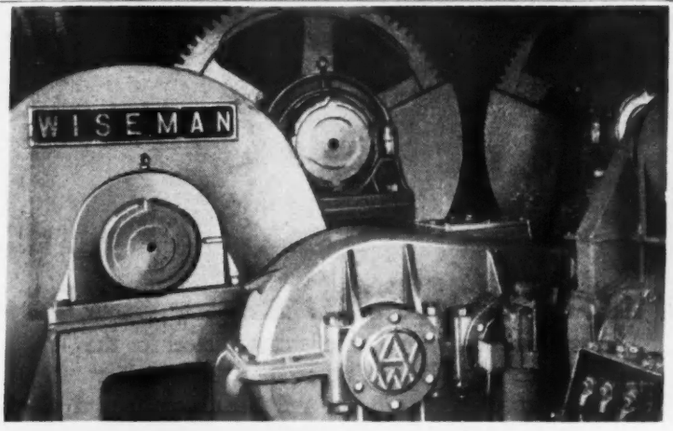

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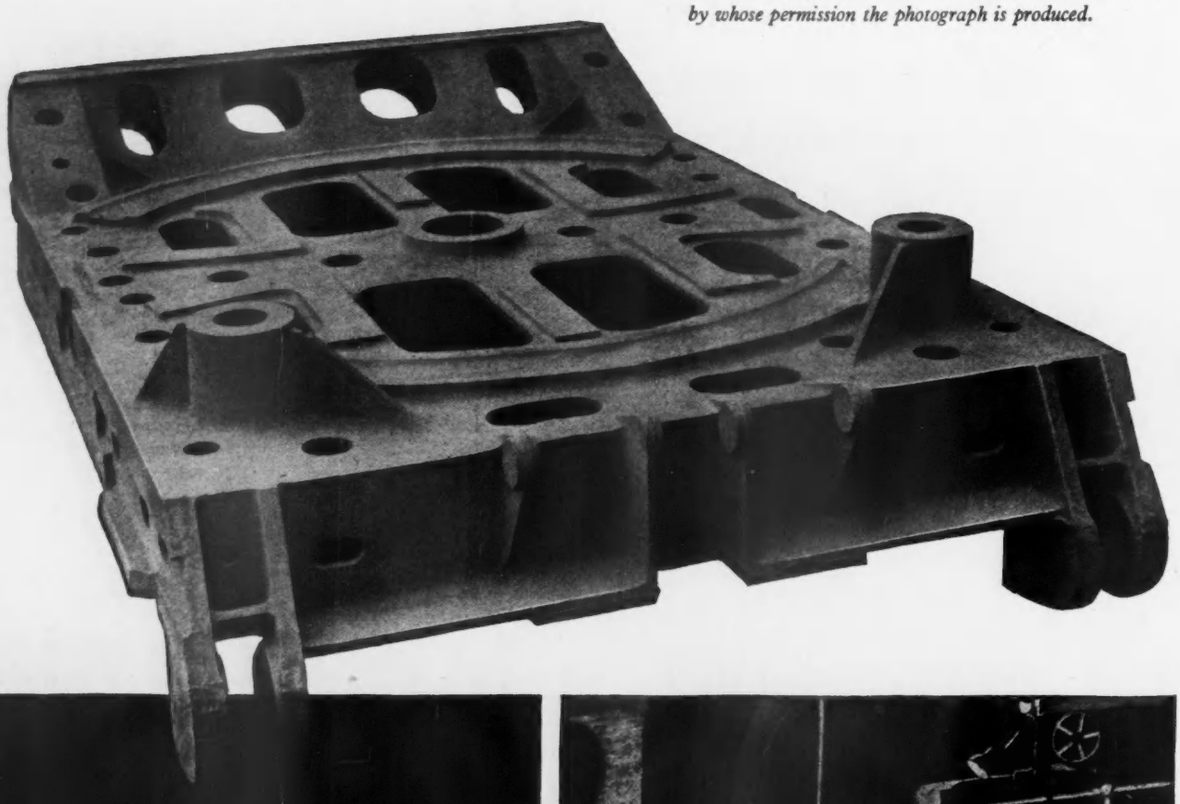
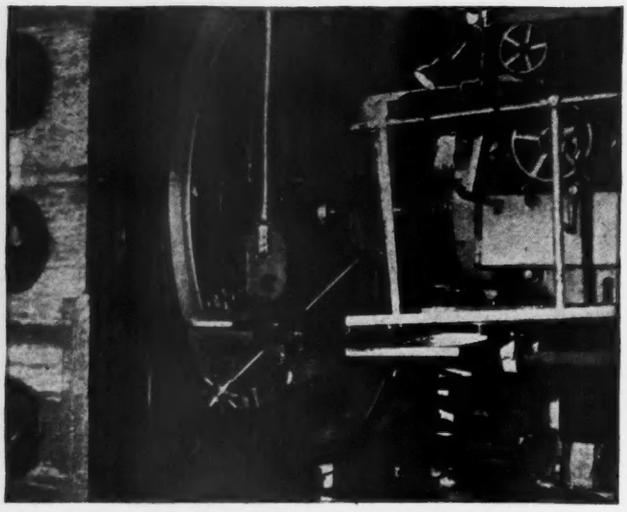
Revolving frame steel casting for the 150-RB excavator, size 10 ft. x 15ft. 6 ins. Cast for Ruston-Bucyrus Ltd. by whose permission the photograph is produced.



cast and machined for an important part



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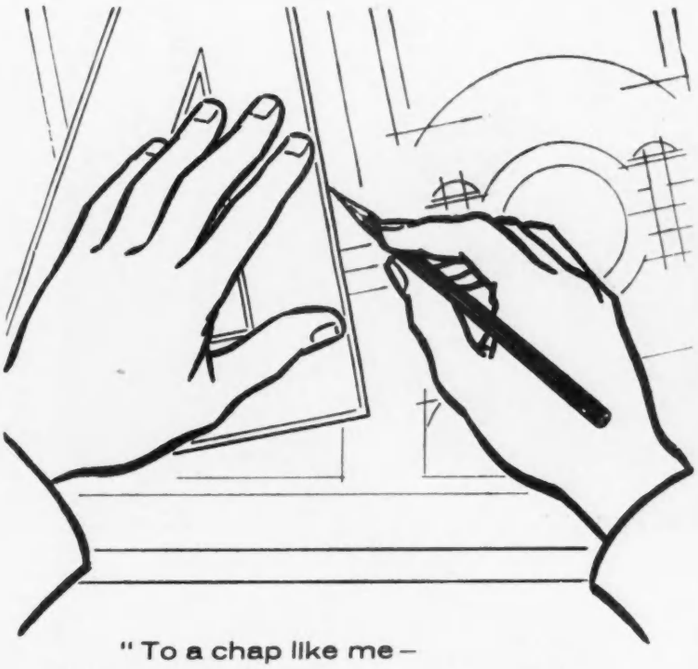

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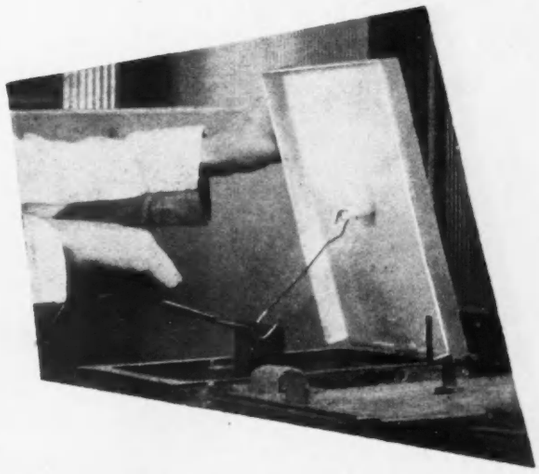

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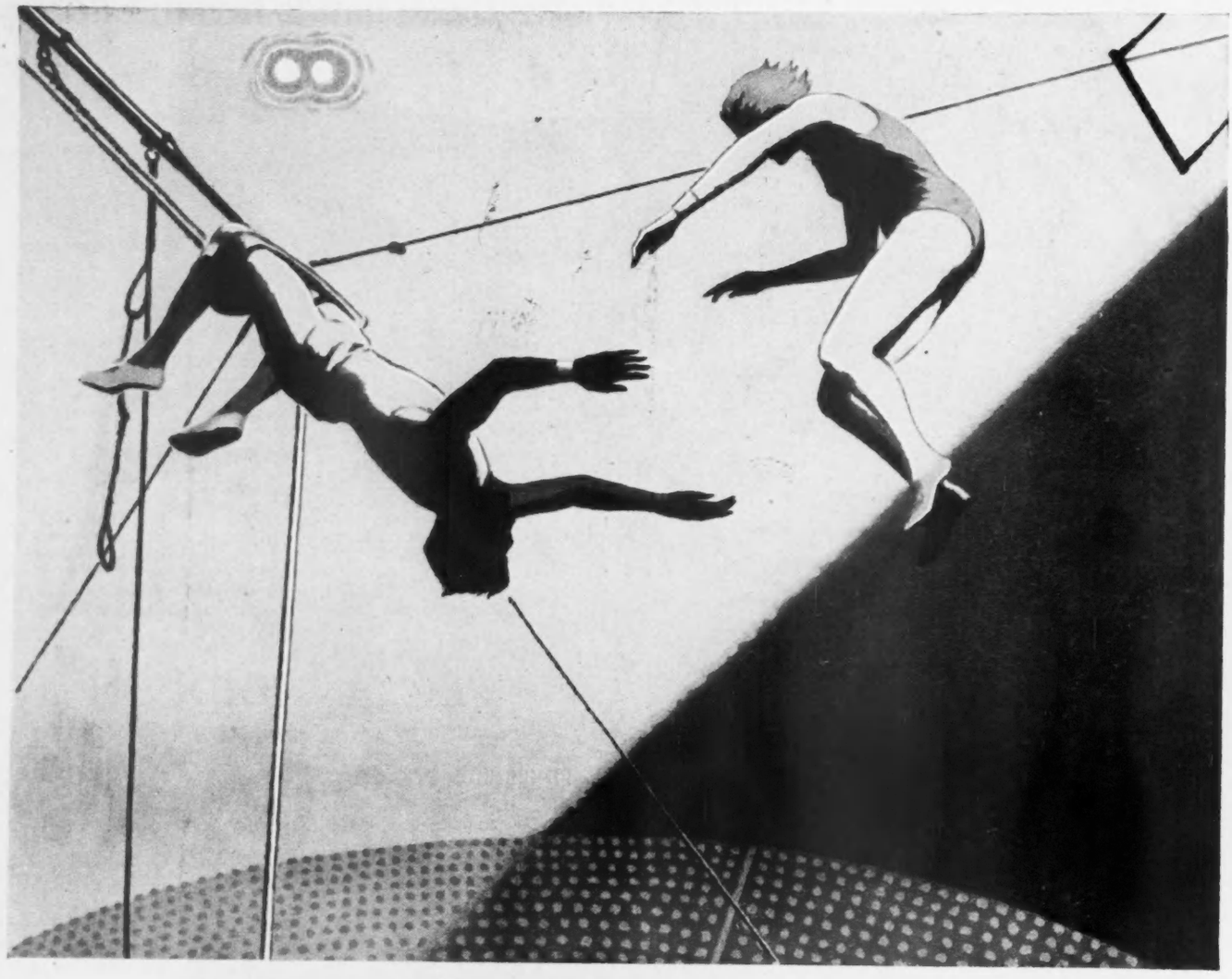

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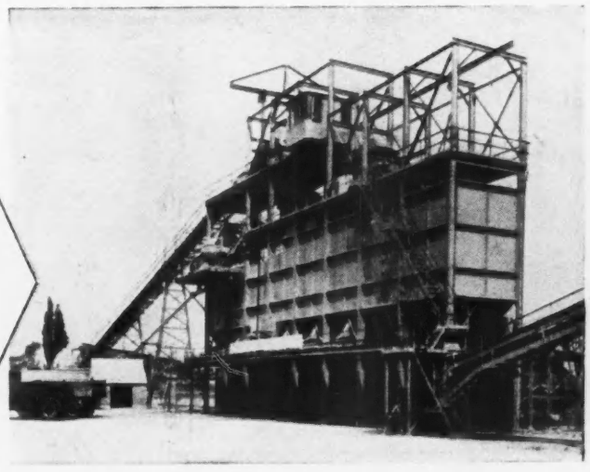

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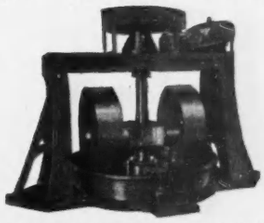

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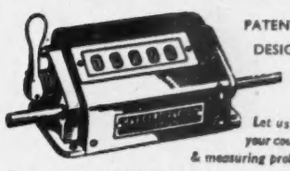

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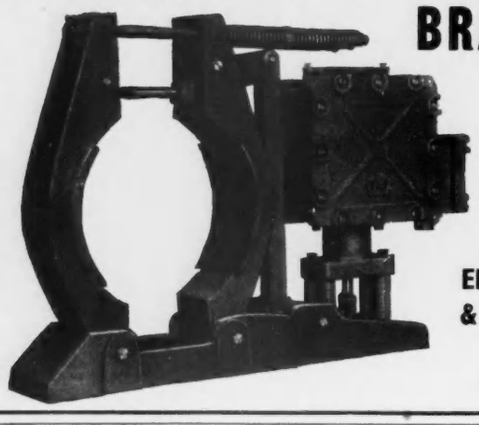

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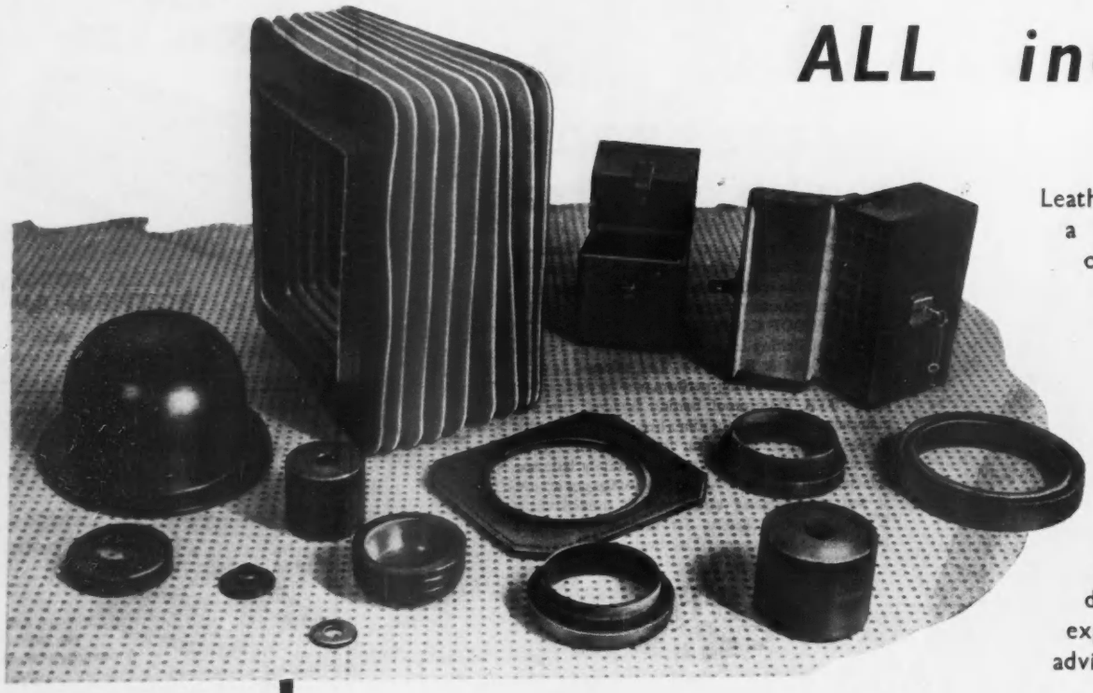

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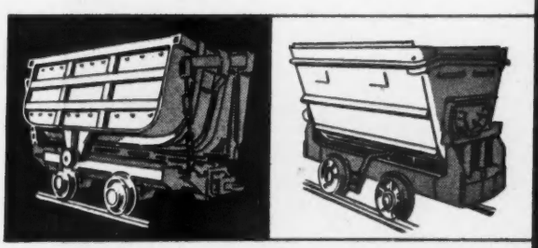

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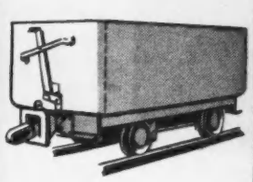

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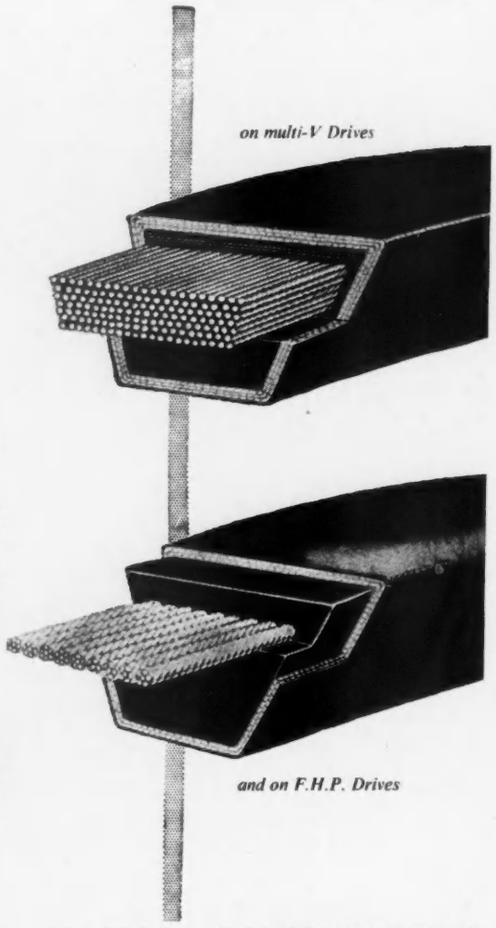

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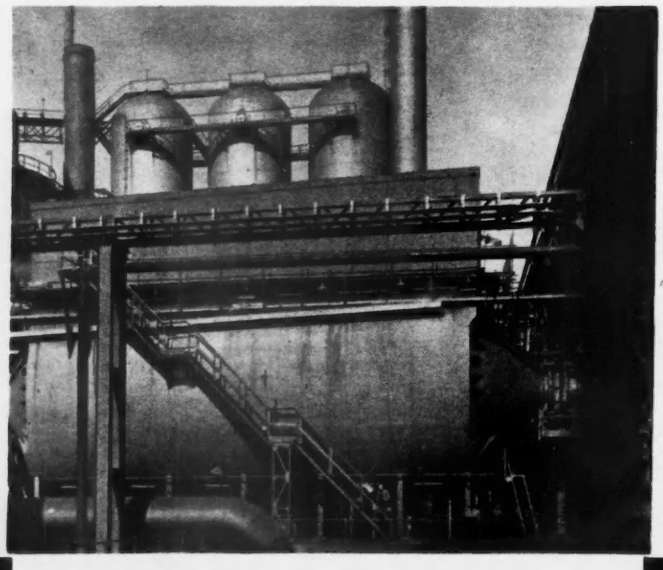

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THE ENGINEER

No. 5357 SEPTEMBER 26, 1958 VOL. 206

LIMITS ON HUMAN ADVANCEMENT

How long, we sometimes wonder, will mankind prove able to maintain the really astonishing rate of advance in material standards of living which has ruled in the West for a half-dozen or so generations and which appears to be accelerating rather than slowing down ? One cannot, of course, claim that sooner or later it *must* stop or at least slow down (which is, no doubt, true) without projecting the curve of advance far, far into the future by which time sheer lack of raw materials in the Solar System might prove a limiting factor. Yet it does seem at least very unlikely that the rate of advance can continue unchecked very far into future generations. A historian might support that latter contention by pointing out how man in the distant past improved his lot by fits and starts. Between each revolutionary period of advance—as seen along the immense span of human history—there are long ages in which almost static civilisations, like that of the ancient Egyptians, flourished. But there is no need to appeal uncertainly to the probability that history will in some degree repeat itself. The seeds of as great a stay in the future can be dimly discerned already. For there are several factors which tend to limit man's power to make advances and some of them may already be acting upon our restless civilisation.

To begin with, one can consider economics. When, in Alexandria about 2000 years ago, Hero invented a reaction steam turbine, it was regarded as a useless toy. For it was economically ridiculous to attempt to develop this machine. There seemed no possibility whatever at that time and in that place that steam power could ever compete in cost with human and animal muscle power. Wages were far too low ! Not until many centuries had passed, and in a very different country where real wage rates were substantially higher, could a steam engine compete economically with muscles ; and only then after Watt had made a radical improvement to the Newcomen engine, thus starting off that restless demand for more and more power per head, so characteristic of our generation. To-day, economics in a similar way might easily bring an end to man's strivings to reach the moon and planets through rockets. For who would dispute that, were it not supported for military reasons, research towards the development of man-carrying space rockets would languish for lack of any sufficient economic incentive for their building ? Upon another tack one can, of course, hardly claim that the limitations of materials set limits upon the span of man's advance. It is undoubtedly true that were materials available better able to withstand stresses at high temperatures, the gas turbine, for example, would very probably by now have ousted the oil engine for all but small powers, just as the steam turbine has ousted the reciprocating steam engine ; and one can think of many other directions in which the limitations of materials restrict man's aspirations. But man makes his advances by discovering more about Nature's " laws " and it is by no means impossible that more will be discovered about metals and alloys or other materials for use under abnormal conditions. Yet, in a different sense, there is a possible " material " limit to man's advance. Man's demands for oil, for example, have been expanding logarithmically throughout this century. Unless, indeed, oil reserves can be assumed to form a substantial fraction of the earth's crust, that kind of expansion cannot possibly be maintained very much longer ; certainly not for more than about a century. A similar argument could be applied to other materials, too.

But there are three other limiting factors acting to-day which may well bring advance almost to a halt in the not very distant future, perhaps within a relatively few generations. There is first of all the increasing difficulty of disseminating satisfactorily all the scientific and technological information that is available. It has been elementary practice for years that before work upon any projected research is undertaken there should be a search of the literature to ensure that the work has not in whole or in part been already done elsewhere. But because that search through the literature is beginning to become in itself a major operation, we have more than once heard the view expressed that, for a minor research, it is quicker and more satisfactory to repeat the research than to search the literature ! Let the flow of published scientific and technological material expand into a flood much greater than exists at present (as it threatens to do) and it may become profitable to undertake quite major researches rather than undertake the expense and labour of searching all the literature. Should any such condition arise, the rate of man's advance must clearly be severely checked because so much of the work done would merely repeat work already done elsewhere. Secondly, advance may be checked by the sheer effort of learning required of anyone before he can reach the boundaries of existing knowledge. Already it is rare for anyone significantly to expand the boundaries before he has reached the late twenties ; and already specialisation (undertaken in order to permit the boundaries of knowledge to be reached at all) has been pressed so far that in all probability the invigoration due to cross-fertilisation is less effective than it used to be. Lastly, we think there can be no doubt that in science the old principle of diminishing returns is operating. The experiments conducted with very simple apparatus and with very little assistance, by, for example, Faraday, had an immense potential value for the human race. By contrast, hundreds of men are to-day hard at work upon researches, some of them very costly, which have far less potential total value than Faraday's ! The influence upon mankind of this diminishing return for the effort exerted in scientific and technological research has been concealed (so that the rate of material advance has been maintained) only by directing into technology a growing fraction of more intelligent youth. But clearly that process cannot be continued indefinitely. Consciously or unconsciously, the community may, sooner or later, decide that too large a fraction of itself is engaged upon work that brings in very small returns. Should that happen, the human race will relapse into a

static civilisation. But we need not apprehend that any such state is only just around the corner. For the present we believe there is no nation in the world which would not profit abundantly from directing a still larger fraction of its more intelligent young people into technological studies than is done at present.

CROSS-CHANNEL POWER CABLE

The project to link the British and French electricity supply systems by a submarine power cable will come one step nearer fulfilment with the carrying out of the sea trials referred to on page 499 of this issue. Such is the pace of progress in electrical engineering that this cross-Channel cable project has been substantially modified in its short history of about ten years. It may be recalled that in 1950, after exploratory discussions, a joint committee was set up by the British Electricity Authority, as it was then, and Electricité de France. Two years of study by this committee yielded the conclusion, in 1952, that there was not enough experience in the design and operation of the conversion equipment that would be needed for a d.c. cable link of commercial size. It was thought, however, that the possibility of a large d.c. experimental transmission, using a spare single-core cable, deserved serious consideration. This was the balance of opinion in 1954, when Sayers, Laborde and Lane presented their I.E.E. paper on the possibilities of a cross-Channel power link. At that stage, therefore, development was concentrated on a cable for a.c. at 132kV, which was considered to be the economic limit. Specimen cables were made, works-tested, and subjected to sea trials by British and French firms ; and a great deal of useful information was obtained about the laying of the cables and their behaviour when laid. Within two years, however, the picture had changed radically, thanks to the installation and successful operation of the 100kV, 20MW cable connection between the Swedish mainland and the island of Gotland. Then, in 1956, came the announcement from Russia that a 200kV, 30MW, transmission over two single-core cables between Kashira and Moscow, 70 miles apart, had been working experimentally for five years ! These installations clearly established the feasibility of the cable and conversion equipment for a d.c. link on a commercial scale. After a fresh reappraisal it was decided, in September, 1956, to adopt d.c. transmission by single-core cable capable of carrying, in each direction, 160MW at 200kV and approval in principle was obtained for such a link, with conversion equipment at each end, between the British and French supply systems.

The interesting point about the sea trials now in progress is that they are designed to prove the practicability of a method of laying two single-core submarine cables, " go " and " return," at a spacing not more than 10ft apart on the sea bed, to limit the electromagnetic effect on ships' compasses. Provided that this novel cable-laying technique proves successful it can be said, without minimising the difficulties that may lie ahead, that the main problems concerning the cables will have been solved. For there is ample experience of submarine power cables, such as the link between Vancouver Island and the mainland of Canada, to suggest that the design and manufacture of the cables will be almost matters of routine. We may look ahead therefore towards the prospect that, in the absence of any serious unforeseen difficulties, the link between the British and French power systems may be in service in time to assist with the winter load conditions of 1960–61. With a power interchange of 150MW between peak periods the link should provide overall economies of the order of £300,000 per annum, quite apart from an anticipated capital saving as between the cost of the link and that of the power generating capacity that would have to be provided in Britain and France if the link did not exist. One of the imponderables at present is the cost of the extensions between the a.c. transmission system and the terminal points of the link. Another unknown quantity, on the British side, is the time required to obtain the necessary wayleaves and complete these extensions to the existing overhead transmission system. Indeed, it is possible that the technical problems to be solved in the design and installation of the link itself may be more tractable than the non-technical obstacles to the erection of the overhead line extensions. We need not anticipate difficulties of this kind, but it would be a pity if the operation of the cable link were to be delayed by the construction of the overhead lines to the terminal points.

B.I.M. AND PSYCHOLOGY

We doubt whether the kind of conference the British Institute of Management held on Tuesday of last week at the Connaught Rooms in London does the reputation of the Institute any good at all. By a coincidence we had the previous day visited a special exhibition at the National Portrait Gallery in London and seen amongst lesser delineations of Oliver Cromwell's features a very remarkable miniature by Samuel Cooper. Somehow, what Professor Tannenbaum had to say at the B.I.M. conference on the subjects of " What Makes Effective Leadership ? " and " A Dilemma of Modern Leadership " seemed to have singularly little relevance in the context of a portrait of one of the greatest leaders this country has ever known. It is, of course, not the fault of Professor Tannenbaum and other academic workers in the same field that more is expected of them than they can possibly provide. The professors of psychology are attempting its study as a science. But they would themselves admit, we think, that they have not yet got very far. Thus, once they pass beyond factual descriptions and factual records of such experiments as they have been able to carry out and start to discuss the kind of " applied psychology" implied by such a term as " leadership " we feel acute discomfort. The facts are often fascinating ; as fascinating as Cooper's delineation of an unattractive man of ruthless determination. But the quality of the discussion tends to remind us rather vividly of the kind of things we all philosophised about when we were in our late 'teens and early twenties with a solemn and earnest faith that somewhere along this road solutions to all the world's troubles would be found. How enjoyable those discussions were, yet how irrelevant to reality !

We have, too, the uncomfortable feeling when we attend a gathering to hear an address on such a subject that many of those present (including perhaps ourselves, which makes matters worse) have come there with the same kind of unholy hope with which the credulous consult astrologers and spiritualist mediums. This is, of course, not the fault of the professors. Indeed, they would be the very first to disavow that there was any magic in what they had to say. Yet many of those who attend hold, we suspect, a secret hope that some nostrum will be produced which will solve for them all their management problems and relieve them of all their responsibilities ; and innocent remarks by the professors that current experiments are expected to throw further light on human reactions to certain circumstances maintain the faith of the credulous that some day the nostrum will be forthcoming.

Does the B.I.M. really need to give attention in this or any other way to the psychological side of management ? Would it not be better to leave the discussion of such matters to other bodies which—we hope the Institute

will forgive us saying so—seem to understand better how to handle them. Other bodies are doing detailed, even if perhaps somewhat elementary, studies under properly controlled conditions into various facets of industrial psychology and they have learned enough to provide elementary courses of real value for junior executives. Need the B.I.M. compete ? Is there not enough scope for that organisation in the study of all the more material techniques of management ?

MACHINE TOOL CONTROLS

At the recent Italian Machine Tool Exhibition in Milan we found that Italian manufacturers, like those in other countries, continue to use on machine tools grouped control systems which are in one respect unnecessarily confusing for the operator. We refer to the current practice of installing grouped push button controls and using only words, symbols or colours, or a combination of them, to identify the particular functions of individual buttons. On most makes of large machines, and particularly those with pendant control boxes, an operator has therefore to take his eyes off the work in order to be quite sure that he presses the particular button for the movement he wants. Should he move to get a better view of the work or swing a pendant, there is plenty of opportunity for him to slip his finger, unawares, to an adjoining similar button. Once this button has been pressed, damage to the machine or work can result because a wrong motion will be engaged. The remedy is so simple that we wonder greatly that it has not been more widely adopted. Surely it would be relatively easy for machine tool makers to introduce a variety of standard simple shapes in button heads so that men could have a check by feel that the correct button has been selected to engage a particular motion. Furthermore, could not simple levers or joysticks be introduced more often instead of installing two or more associated directional buttons ? These levers could readily be made distinctive to the fingers by different shapes of heads. No doubt, after he has spent some time working on a machine an operator habitually selects the correct push button in grouped controls, just as a typist selects the right keys, without looking. But learning takes time. Little damage is done if a typist presses the wrong key. But lots of damage can be done to the tool, the work and/or the machine if an operator engages the wrong motion. The use of directional levers and " touch-identifiable " buttons should shorten the learning period. But, just like a skilled typist, an operator fully acquainted by long custom with the controls may occasionally press a wrong key or button. Touch-identifiable buttons would provide warning that a mistake was about to be made and thereby save spoiled work or other damage.

SAFETY AT WORK

The steady improvement which continues to be made in this country in the important matter of industrial safety is rightly emphasised in the annual report of the Chief Inspector of Factories. Last year, the total number of notified accidents in establishments subject to the provisions of the Factories Acts was 174,713. It was the lowest recorded for twenty years and, with the exception of one year, followed a trend which has been evident throughout that period. Of last year's accidents, 651 were fatal and 174,062 were non-fatal, both of which figures were 5 per cent lower than those for the preceding year. The number of people employed in the various establishments was much the same in both years, though during last year the actual number of factories continued to decline. The report shows, in fact, that in the last seven years the number of smaller factories without mechanical power has fallen from 29,898 to 14,660. This is not surprising, of course, when the rapid increase in factory mechanisation of all kinds is kept in mind. But the report notes also that a higher standard of safety in outdoor work—on building sites and the like—coming within the purview of the factory inspectorate is being maintained, the number of fatalities in this category being 16 per cent lower last year than in 1956.

Undoubtedly, safer working methods and improvements in the design of all kinds of machinery and equipment are making a valuable contribution to the better standard of safety at work which is being experienced. The constant elimination of hazards is of the highest importance. Yet it seems reasonable to suggest that the expenditure of time, trouble and money in the business of safety training is now beginning to show some worthwhile results. It may well be, as the report says, that " developments in this sphere offer the main prospect for further advance in reducing the toll of accidents in industry." There is no doubt that through systematic training and the continued stimulation of co-operation between management and workers " safety consciousness " can be encouraged. In reporting last year's improvements, however, the Chief Inspector wisely adds a word of warning about complacency. There is room for further improvement, for even though last year's figures were the lowest for twenty years, there are still far too many industrial accidents.

The Engineer — 100 Years Ago (SEPTEMBER 24, 1858)

" THE ATLANTIC TELEGRAPH."

" After all our rejoicings over the great achievement of laying the Atlantic Telegraph, it is extremely mortifying and humbling to have the great result daily sliding away from our grasp .... It is possible that the cable is being slowly sawn in two on the craggy points of the submarine Alps that form the descent to the great Atlantic plateau, some 270 miles from Valentia. Whilst the cable was settling down to its position on the aclivities of this rocky ascent, some accident or miscalculation prevented the fact being known on board the Agamemnon, and, consequently, sufficient slack was not allowed to suffer the cable to sink down into all the fissures and ravines of that subaqueous mountain chain. The probability is, that it is stretched taut across one of those yawning gaps, and is being slowly abraded on the craggy point that edges the gulf .....

" But is all lost ? Let us calmly look the matter in the face ; and allowing that the worst fortune possible overtakes the present cable, that it becomes useless and irrecoverable, even then there is doubtless a large balance of gain remaining. It has been demonstrated that a cable *can* be laid across the Atlantic .... As to the possibility of avoiding the mistake the Agamemnon made in not lightening the pressure on her brake at the proper time, there can be no doubt. If there be any truth in a navigator's calculations, the proper point for this is calculable with sufficient exactness. It really then amounts to just this. The first cable has been all but completely successful. It has failed by the smallest chance possible. But it has demonstrated the way to certain success hereafter, and it will be mere wilfulness if the causes of fatality in it are not hereafter avoided. That we shall soon have a perfectly successful Atlantic telegraph no man can doubt."

Friction and Lubrication of Machine Tool Slideways

By T. M. BIRCHALL, B.Sc.,* and A. I. W. MOORE*

An investigation into friction and lubrication of machine tool slideways and the influence of the type of surface, lubricant viscosity and load on friction characteristics is being carried out by the Production Engineering Research Association. A summary has been received from the Association of the first part of the work, which was carried out with the general object of determining the effect of type of surface.

A SERIES of investigations is being carried out by the Production Engineering Research Association (P.E.R.A.) which is aimed at providing design data for the slideways of machine tools. The first part of the work which is summarised† here was carried out with the general object of determining the effect of type of surface (i.e. hand scraped, periphery ground and cup ground), lubricant viscosity and load on the lubrication conditions (i.e. boundary, mixed or fluid film) that occur between flat surfaces under substantially parallel sliding conditions. Of special interest were the effects of these factors on kinetic and static friction, stick-slip, and the onset of full fluid film lubrication.

Terminology.—The terms boundary, mixed and fluid film lubrication conditions are taken to have the following meanings :

Fluid film or hydrodynamic conditions : When the sliding surfaces are completely separated by a lubricant film of appreciable thickness. Under these conditions the resistance to motion is due entirely to the viscosity of the lubricant film and no wear of the solid surfaces takes place.

Boundary conditions : when the sliding surfaces are separated by lubricant films of only molecular dimensions. Under these conditions the friction is influenced by the nature of the underlying surface as well as by the chemical constitution of the lubricant. The bulk viscosity plays little or no part in the frictional behaviour.

Mixed conditions : when there are localised areas of fluid film lubrication with the remainder of the bearing area under boundary conditions.

Slideways for machine tools may be classified into two main groups, those which are associated with cutting tool feed rates and operate in the low-speed range from about 0·1in to 50in per minute, and those which are associated with cutting speeds and operate at relatively high speeds of 150ft to 500ft per minute or more. The first group includes sliding units for milling and horizontal boring machine tables, planer and vertical boring mill heads, lathe saddles and grinding machine wheel heads. The second group includes planing machine tables, shaping machine rams and vertical boring mill tables. Certain types of sliding system fall outside these groups, since tables operating at slow feeds are often provided with quick traverse mechanisms, and grinding machine tables, for instance, operate at speeds up to 100ft per minute. In addition, very low sliding speeds are now frequently necessary in the operation of some forms of contouring and automatic positioning mechanisms.

The loads on slideways arise from the weight of the sliding unit and the workpiece, if this is carried on the sliding member, together with the forces set up by the cutting action. In some cases the weight of the table and work may be considerable compared with the forces set up by the cutting action and in other cases the cutting forces may contribute the greater part of the load.

The desirable properties of machine tool slideways are freedom from wear, scoring and seizure ; good friction characteristics, including absence of stick-slip ; accuracy of straight line motion; and adequate load carrying capacity. Several schemes have been introduced with the object of improving some of these features and include rolling bearing slides, hydrostatic slides, plastic materials and various types of lubricant.

The majority of machine tool slideways in this country consist of a cast iron on cast iron combination. This allows the simple and economical system of using a relatively inexpensive constructional material to form both the structure of the machine and the surfaces of the slideways. Despite the fact that the operating conditions for various types of machine are very different, the basic form and design of the majority of machine tool slideways are similar ; two nominally parallel plane surfaces are arranged to slide together and provision is made for introducing a lubricant. A number of such surfaces may be combined in various ways to provide the different slide arrangements such as vee and flat, double vee and dovetail. The conventional methods of preparing the cast iron sliding surfaces are by scraping or grinding, the choice of method quite often depending on production rather than functional requirements. The loading on the slideways is usually expressed in terms of the total load divided by the bearing area, and common values range from 10 lb to 80 lb per square inch. However, owing to asymmetrical loading conditions and divergencies from true plane surfaces due to machining errors and deflections, it is highly probable that the load per unit area reaches much higher values at certain points on the slideways.

Although much fundamental work has been done on problems of friction and lubrication, little is directly applicable to machine tool slideways. The work described here was designed to form a foundation for further studies of the behaviour of machine tool slideways. Conditions obtaining in the test equipment simulated as closely as possible the conditions in part of a typical machine tool slideway and yet permitted much greater control of such factors as geometrical accuracy, distribution of load and lubricant supply. The results obtained elucidate the fundamental lubrication mechanism involved over contiguous parts of the sliding surfaces.

The load on machine tool slideways is not uniformly distributed over the sliding surfaces and will depend on the particular element of the contact area which is under consideration. The resultant friction force on the machine tool slideway thus involves the summation of the contributions of individual elements. The form of the coefficient of friction/sliding velocity relationship is altered on account of this. In place of a steeply descending curve, a much shallower curve is to be expected since the averaging process tends to obscure the basic relationship between coefficient of friction and sliding velocity. Part of the utility of this investigation is that the underlying effects are sharply defined, whereas with larger scale equipment they tend to be masked due to this averaging process.

A variety of factors may affect the friction characteristics of sliding surfaces, for example, scale effects of various types including that just discussed ; questions relating to the supply of lubricant ; rubbing effects due to particles entrapped between the mating surfaces ; and many other matters peculiar to actual machine tool slideways. Further

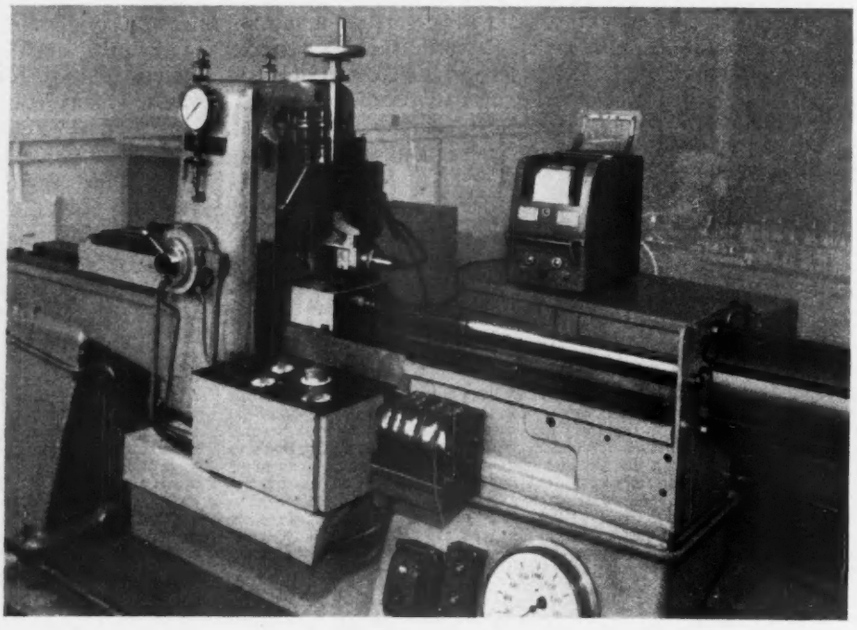

Fig. 1—Friction testing machine

* Senior Research Engineer, Production Engineering Research Association.

† Copies of the full report can be purchased at a cost of £1 1s. from the Secretary, P.E.R.A., Melton Mowbray, Leics.

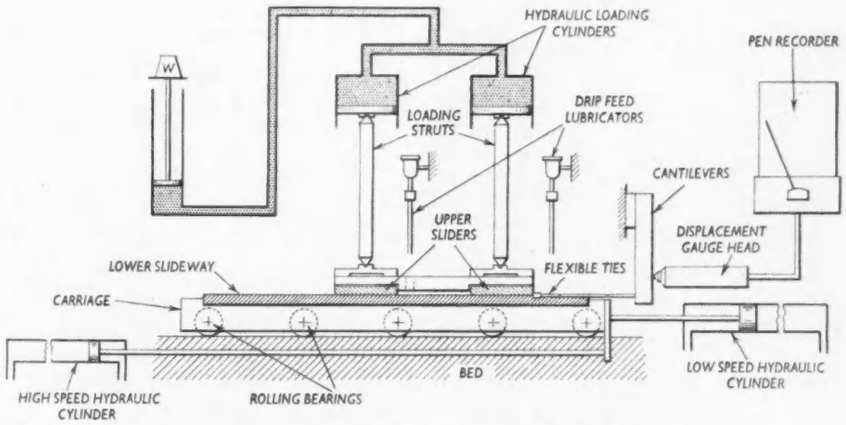

Fig. 2—Schematic arrangement of P.E.R.A. friction testing machine

work is now in progress to investigate some of these additional effects.

The majority of machine tools have a cast iron on cast iron slideway combination; cast iron was selected therefore as the material for the test slides. Three pairs of sliding surfaces were prepared in three different ways, namely, by hand scraping, periphery grinding and cup grinding. Numerical values of the surface finish of each test surface are given in Table I.

TABLE I—*Values of Surface Finish of Sliding Surfaces*

	Direction	Surface finish μ in C.L.A.		
		Hand scraped	Cup ground	Periphery ground
Upper slider	Longitudinal	22	14	4
	Transverse ...	21	6	7
Lower slideway	Longitudinal	24	14	4
	Transverse ...	25	12	8

So that viscosity effects would not be confused with boundary lubrication effects, the lubricants used were straight mineral oils containing no boundary additives. The three lubricants used had nominal viscosities of 100, 500 and 1500 Redwood I seconds at 70 deg. Fah. Two test loads of 20 lb and 50 lb per square inch were used as these were considered fairly representative of the range of loads generally encountered in machine tool slideways.

Friction Testing Machine

As previously mentioned, the performance of conventional machine tool slideways is probably influenced by numerous variable factors which are not easily isolated. For this reason the special equipment shown in Fig. 1 was constructed for the investigation. A schematic layout indicating the essential features of the machine is shown in Fig. 2.

Fig. 3—Lower test slideway

The machine consists basically of a cast iron bed having horizontal slideways which are machined flat and parallel. A cast iron carriage fitted with five pairs of roller bearings runs on the horizontal bed slideways and is guided by two pairs of ball bearings which roll on vertical machined faces on each side of the bed. The carriage can be reciprocated by either of two hydraulic cylinders at velocities varying from approximately $\frac{1}{16}$in to 350in per minute over a stroke of 30in. Provision is made for measuring the velocity of the carriage, and a system of trip dogs and valves enables the carriage to be reversed or stopped at any position of its stroke.

The lower test slideway (Fig. 3) which is 30in long by 5in wide is fixed to the moving carriage. The upper slider assembly (Fig. 4) which slides on the lower slideway consists of two cast iron pads 3in long by $3\frac{3}{8}$in wide spaced 4in apart and secured to a steel bridge piece. Motion of the upper slider assembly is restrained by a force measuring system. Lubricant is supplied at two points in front of the leading edge of each pad of the upper slider by two drip feed lubricators. In order to reduce effects due to ambient temperature changes to a minimum, the equipment was installed in a room in which the temperature could be controlled to within 4 deg. Fah. under most conditions.

The load is applied to the centre of each of the two pads of the upper slider through ball-ended struts by two hydraulic piston and cylinder assemblies. Oil under pressure is supplied to these cylinders from a hydraulic accumulator which ensures a uniform pressure free from pulsations. The required oil pressure is obtained by placing suitable dead weights on the accumulator piston. This arrangement permits a constant load to be applied to the sliding surfaces even in the event of any movement of the upper slider in the vertical direction. Oil pressure, and hence the load applied to the slideway surfaces, is determined by means of a pressure gauge coupled to the hydraulic system in close proximity to the loading cylinders.

This arrangement employing a two-pad upper slider, each independently loaded, was contrived in order to minimise the possibility of a "tilted-pad" effect occurring. It was thought that the possibility would have been very real if a single-pad slider had been used.

The friction force is measured by arranging the force to be resisted by a pair of cantilevers whose resulting deflection is recorded and electrically amplified (see Fig. 2). The upper sliding surface is connected by means of flexible ties, one on each side of the slider, to the extremities of two relatively stiff cantilevers. The flexures are designed to impose no constraint on the slider in a vertical direction and are positioned so that the restraining force is in the plane of sliding. The two cantilevers are connected by a cross beam, the centre of which is in contact with the stylus of the displacement gauge head. Thus, as the lower sliding surface is traversed, the friction force tending to carry the upper slider with it deflects the cantilevers and hence the stylus of the gauge head. The resultant signal from the gauge head is amplified and fed to the "Talymin" pen recorder.

The friction force measuring system was calibrated by applying incremental horizontal forces to the pair of cantilevers by means of weights and pulleys. The resulting deflection of the cantilevers induced deflection of the pen on the pen recorder, the scale of which was then calibrated in pounds. Two ranges were available on the pen recorder which corresponded to friction forces of 0 lb to 450 lb and 0 lb to 90 lb. On the former range, the friction force could be read to an accuracy of ± 1 lb and on the more sensitive range to $\pm\frac{1}{4}$ lb.

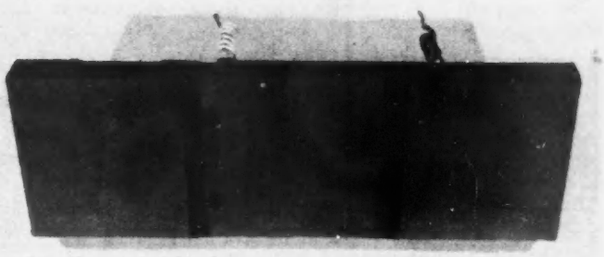

Fig. 4—Upper slider assembly

Results

Variations in coefficient of friction with sliding speed were investigated over a range of speeds from $\frac{1}{16}$in to 350in per minute. A typical curve plotted on logarithmic-linear scales is shown in Fig. 5. The curve commences at low sliding speeds with a divided portion represented by broken lines

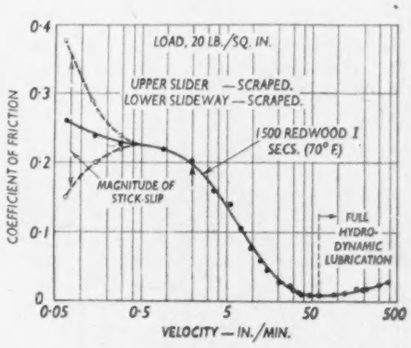

Fig. 5—Typical curve showing variation of coefficient of friction with sliding speed

which indicate the magnitude (in terms of coefficient of friction) of the stick-slip motion. As the sliding speed increases, the coefficient of friction decreases as a greater proportion of the load is supported by partial hydrodynamic films. Eventually a point is reached where the coefficient of friction has a minimum value and under these conditions the sliding surfaces are completely separated by a lubricant film whose thickness is of the order of magnitude of the surface irregularities of the sliding members. At sliding speeds above this point, the coefficient of friction increases according to the laws of hydrodynamics.

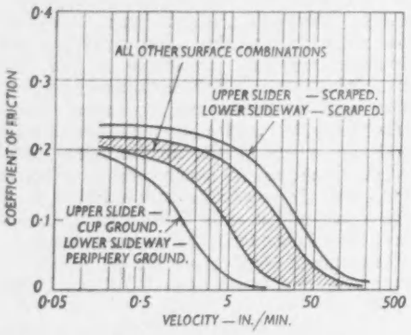

Fig. 6—Effect of various surface combinations on kinetic friction

It was noted during the tests that as the sliding speed increased, the amplitude of stick-slip decreased until it could no longer be recorded with the instruments used. This point is shown on the curve where the broken lines converge into the single curve. At speeds beyond this point, however, stick-slip was in most cases still detectable by the presence of a vibration in the sliding unit. The point at which stick-slip was no longer detected is indicated on the curve in Fig. 5 by an arrow.

Fifty-four curves similar to that shown in Fig. 5 were obtained for every possible combination of the three lower slideway surfaces, three upper slider surfaces, three lubricant viscosities and two loads. In order to present the results in a manner which would enable the main effects to be readily studied, they were statistically analysed and a series of average curves was constructed. In the construction of these average curves, stick-slip was neglected, the mean of the stick-slip envelope being taken as the continuation of the kinetic friction curve. A separate analysis was carried out to determine the effects of the variable factors on stick-slip.

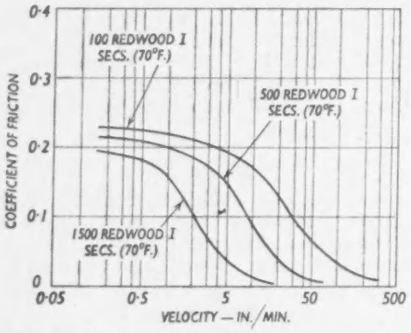

Fig. 7—Effect of lubrication viscosity on kinetic friction

Effect of Type of Surface on Kinetic Friction.—The average curves depicting the effects of the various sliding surface combinations on kinetic friction are shown in Fig. 6. At all sliding speeds, up to that at which full fluid lubrication occurred, the coefficient of kinetic friction was highest with the scraped surface combination.

The cup ground upper slider with a periphery ground lower slideway exhibited a lower coefficient of kinetic friction than the other surface combinations through the region of boundary and mixed lubrication.

The remaining surface combinations gave rise to intermediate effects and are all contained within the shaded area in Fig. 6.

Effect of Lubricant Viscosity on Kinetic Friction.—The average curves depicting the effect of lubricant viscosity on the friction/speed relationship are given in Fig. 7. These show that, as would be expected, for all sliding speeds up to that at which full fluid film lubrication occurred, the lubricant of highest viscosity exhibited the lowest coefficient of kinetic friction.

Effect of Load on Kinetic Friction.—The effect of load on kinetic friction is shown by the average curves in Fig. 8. At sliding speeds below approximately 7in per minute the lower load (20 lb per square inch) exhibited the higher coefficient of friction. At higher speeds, however, there was little difference in the friction for the two loads.

Effect of Various Factors on the Sliding Speed at which Full Fluid Film Lubrication Occurred.—In order to show the effects of the various test factors on the sliding speed at which full fluid lubrication occurred, the results are presented in the form of a bar chart (Fig. 9). The most favourable conditions for complete separation of the sliding surfaces were a high viscosity lubricant, low load and ground surfaces. The worst conditions from this point of view were a low viscosity lubricant, high load and scraped sliding surfaces.

Effect of Various Factors on Static Friction.—The results indicated that the only factors which had a marked effect on the coefficient of static friction were lubricant viscosity and type of surface of upper slider. The type of surface of the lower slideway did not appear to affect static friction. The effects of the two factors are shown in Fig. 10 which indicates that the worst conditions from a static friction aspect were a scraped slider and low viscosity lubricant.

Effect of Various Factors on Stick-Slip.—The effects of various factors on the speed range over which stick-slip was detected are shown in the bar chart (Fig. 11). This chart indicates that the worst conditions from the point of view of persistence of stick-slip were a low viscosity lubricant, high load and scraped sliding surfaces.

The factors which affected the magnitude of stick-slip (i.e. the difference between the friction at stick and the friction at slip) over a limited range of sliding speeds are shown in Fig. 12. The curves show that at a sliding speed of 0·1in per minute, the magnitude of stick-slip was influenced both by the load and the type of surface of the upper slider. At this speed the high load and scraped slider caused the maximum severity of stick-slip.

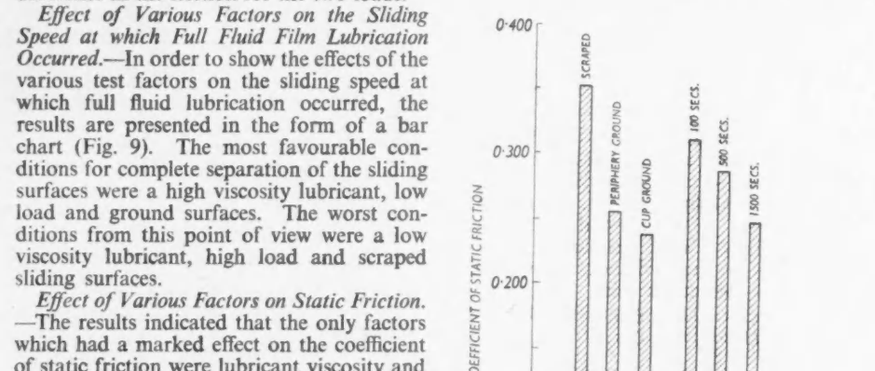

Fig. 9—Effect of various factors on the speed at which full fluid film lubrication occurred

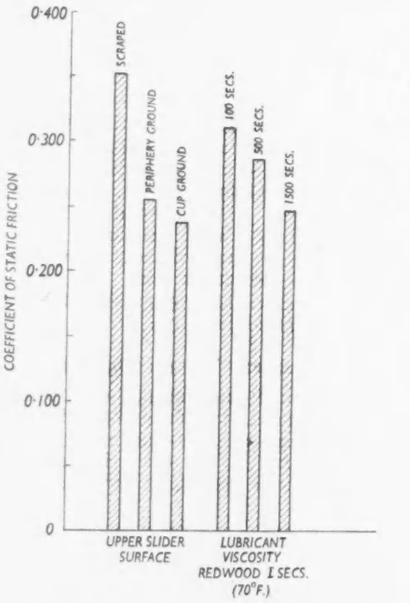

Fig. 10—Effect of various factors on static friction

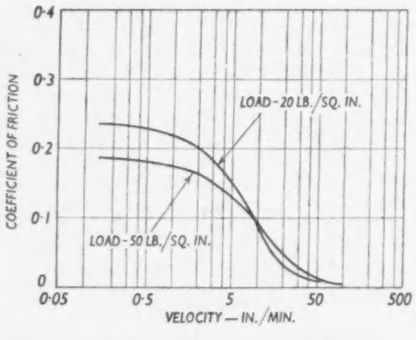

Fig. 8—Effect of load on kinetic friction

The effect of the slider surface became less pronounced with increased sliding speed until at a speed of 0·3in per minute only the load had a marked effect on the magnitude of stick-slip.

Remarks

Although a considerable amount of data has already been obtained, the investigation should not be considered in any way complete. Much remains to be done to provide a more complete understanding of the mechanism of lubrication between substantially parallel sliding surfaces. As previously

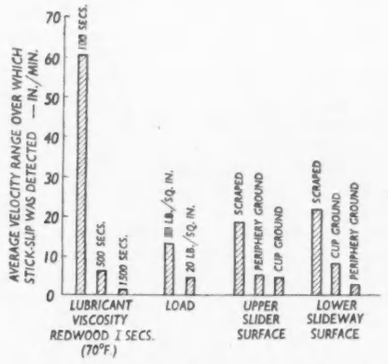

Fig. 11—Effect of various factors on stick-slip

mentioned, many additional factors may affect the performance of a machine tool slideway in practice, such as various scale effects, lubricant supply, effects of foreign particles in the lubricant and standing time. Thus, although the results of this investigation showed that in general the frictional characteristics of the ground surfaces were superior to those of the scraped surfaces, extraneous factors related to particular conditions of service may sometimes favour the use of scraped surfaces.

Where such conditions exist, possible

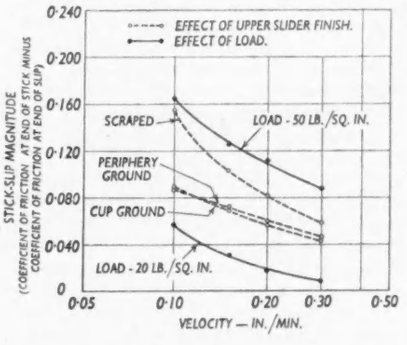

Fig. 12—Effect of various factors on the magnitude of stick-slip

reasons for the better results frequently claimed for scraped surfaces may be :

(1) In some cases where the distribution of lubricant is inadequate, scraped surfaces may provide flow paths which allow lubricant to gain access to areas which might otherwise be starved of lubricant.

(2) Scraped surfaces can probably be prepared to a higher degree of flatness and, therefore, conformity, thus distributing the load on the slideway more effectively and reducing the tendency for localised regions of high loading.

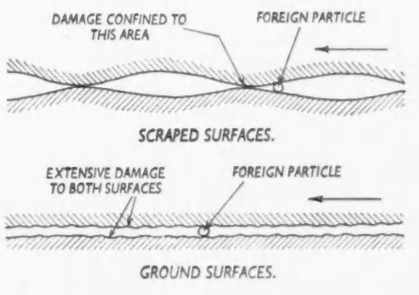

Fig. 13—Comparison of effects of foreign particles entrapped between a pair of scraped surfaces and a pair of ground surfaces

(3) Foreign particles in the lubricant may be passed between scraped surfaces without causing excessive damage. If contact does occur, it is probable that the damage will be confined to a localised high spot on the scraped surface. On the other hand, such a particle contacting closely mating ground surfaces would be likely to cause surface damage which would become more severe and extend over a much greater area. This is illustrated in Fig. 13.

(4) After a slideway has been at rest under load for a considerable period of time, most of the lubricant would be squeezed out from between ground surfaces. In the case of scraped surfaces, however, small reservoirs of oil may remain in the scraped pockets and thus provide initial lubrication of the surfaces until the normal mechanism of lubrication comes into effect.

Summary.—This investigation has demonstrated the fundamental frictional behaviour of flat cast iron slides under substantially parallel sliding conditions when lubricated with an adequate supply of clean mineral oil. By making use of these results and bearing in mind the possible influence of other factors, including those already mentioned, designers will be able to form some idea of the type of lubrication to be expected in a machine tool slideway under a fairly wide range of conditions.

In order to supplement the data provided by this investigation, work is continuing at P.E.R.A. to study scale effects, lubricant supply and other factors on larger scale equipment which has recently been constructed. The performance of different additive type lubricants, solid lubricants such as molybdenum disulphide, and of various slideway materials including plastics, is also being examined. These investigations will provide further design data for machine tool slideways.

Non-Dimensional Groups as Criteria of Process Plant Dynamics

By F. V. A. ENGEL

Similarity and model research have been extensively based on non-dimensional groups. These groups should also be used as important tools and criteria in investigating process plant dynamics. In general, the application of such groups has been badly handicapped by their apparently unrestricted number. The main task of the present investigation is to limit the number of the groups pertinent to fluid dynamics and heat transfer. Axiomatic outlines and the comprehensive set of differential equations result in six groups. Stringent rules for the integral components of the groups are required. The velocity term is an essential integral component of each genuine group of dynamics. The Strouhal number is introduced as characterising the unsteady state. Each of the six groups represents a distinct quality or feature, indicated by their position in the axiomatic system, as well as their relation to special terms in basic differential equations. The meaning of "completeness" of the system of groups is discussed, which differs from previous publications on this subject. The genuine groups are dealt with as "independent" variables characterising irreversible processes. Their practical application is somewhat restricted by lack of information on the correct manipulation of the groups. The present investigation indicates certain limits in the mathematical manipulation. It is recommended that the genuine non-dimensional groups of dynamics should be applied separately, and merely as "test functions."

NON-DIMENSIONAL groups have been successfully used in model investigations in the fields of aerodynamics, shipbuilding, fluid mechanics, thermodynamics and other branches of engineering. The engineer was mainly interested in obtaining important design characteristics for his prototype. This way of approach gave him a valuable tool in all cases where other sources of information were either insufficient, or when various pertinent factors were simultaneously influencing plant behaviour. Particularly in the latter mentioned case it may happen that one or the other factor is still unknown, or its influence under-estimated, resulting in so-called "scale effects." These "scale effects" unfortunately introduce in some ranges a degree of uncertainty in the choice of correct dimensions. A better understanding of the meaning of the true non-dimensional groups and some restrictions in their manipulation may help to reduce the magnitude of or even eliminate scale effects altogether. This is only one aspect of the present investigation, as it is mainly directed to present a complete set of groups for studying plant dynamics.

Process engineering requires a careful study of the unsteady state in contradistinction to model techniques, which are merely based on steady state conditions. In two schemes deriving non-dimensional groups, which are outlined in the following sections, the Strouhal number is introduced, representing a special criterion of the unsteady state. Process plant dynamics should inquire into both the steady as well as the unsteady state. However, in the past, process instrumentation, as a means of interpreting plant behaviour, has been mainly relied upon to investigate and establish steady state conditions. Pressure and temperature, representative of a static concept of plant behaviour, in addition to the rate of flow, are still the usual type of measured values. Further progress in design and control of continuous processes can only be achieved by a careful study of plant dynamics, including the unsteady state. The latter has to be considered when any kind of disturbances are encountered due to various changes in conditions; for instance, the composition of the products to be processed, changes in reaction rates which may influence the time constants of the system and other influencing factors. The problems are rather involved as most of the processes—besides chemical reactions—are characterised by rate of flow, heat and mass transfer. Many of the modern processes like fluidisation, distillation in packed columns, and absorption or adsorption of gases require at least a careful consideration of flow and heat transfer conditions in the plant.

Knowledge of plant dynamics should assist the control and the process engineers in selecting optimum operation conditions and the correct choice and setting of the control

gear. The meaning of plant dynamics may be illustrated by reference to an example. A fluidised bed operates between two limits, the fixed bed characterised by a fluid velocity insufficient to support the particles, and a velocity which is sufficiently high to transport the particles out of the reactor. There is an intermediate stage when the drag exerted upwards is just counteracting the downward directed forces and is equal to the weight of the particles. The question arises, whether or not there are any tools of investigations available to solve related problems. The answer is that there are so-called non-dimensional groups of dynamic similarity, which can be used to analyse the dynamic behaviour of fluidised beds over a considerable range of velocities, and other pertinent features.

The same example affords further means of interpretation and illumination of the meaning of plant dynamics. It is evident that irregularity of size and shape of particles in fluidisation processes may be connected with a high noise level. Of course, there are many other causes of noise in such plants. Furthermore, as the process is characterised by pressure loss, it is essentially an irreversible, or one-way process. This means that the process has non-linear characteristics. There may be only a small range between the noise level on the one side and the non-linear characteristic on the other side. It may be even doubtful if there exists at all a linear characteristic to any extent. Under those conditions it is not permissible to apply to such processes the technique of frequency response analysis or the transient method, which has been recently advocated for studying control stability. The present example should serve as a warning, that the knowledge of plant dynamics inherent to each process should be established before applying inadequate tools of investigation. The main section of this article will show that there is a criterion of dynamics, a frequency parameter, which should be considered before any generalised statement is made on process plant dynamics.

At present the information on plant dynamics, as outlined, is very scarce. Some investigators present their results on a basis which is hardly applicable to other even similar plants. The confusion in the fields of plant similarity and performance is still increasing due to some misunderstanding and misinterpretations of the true laws of dynamic similarity.* Furthermore, some of the permissible mathematical manipulations of the various dynamic criteria appear not to be founded on sufficiently stringent rules. The outlines, as given in the present investigation, are intended to establish a more secure and general way of approach. The chief aim is the development of a complete set of criteria, which characterise process and plant dynamics.

A Complete Set of Genuine, Non-Dimensional Groups of Dynamic Similarity

Derivation of Non-Dimensional Groups.— Two schemes of introducing a complete set of non-dimensional groups reveal their physical significance. The importance of stressing the physical meaning is often overlooked, particularly in cases of rather formalistic ways of deriving the non-dimensional groups, for instance, from the Pi Theorem.

The first method is based on a set of differential equations, namely, the Equation of Continuity, the Navier-Stokes Equations, the Energy Equation and the Equation of State. It will be shown that each non-dimensional group is related to a specific term in the equations, emphasising its physical meaning. The other method is an axiomatic correlation of all dynamic quantities and qualities, which represents the complete set of non-dimensional groups and allocates these terms to the entire system of dynamic entities.

The dynamics of process plant behaviour in all its aspects can only be grasped if it is referred to time-dependent conditions. A scheme presented in a book on Gas Dynamics (Oswatitsch[14]) can be readily applied to our special task. However, the interpretation of some of the non-dimensional terms has to be qualified.

Any process which is characterised by flow and heat transfer may be represented by the original set of differential equations, as given in Table I. The usual procedure is to transform these equations in accordance with linear scale ratios. The various transformation rules are also given in Table I. They form an essential step to establish dynamically similar conditions. In general, they are applicable to the scaling up of a pilot plant to the full scale plant or prototype. The latter may differ considerably in its geometrical dimensions. When investigating plant dynamics the overall geometrical dimensions, however, will be kept constant, presenting a specific case of the more general assumption, as given in Table I. This statement does not exclude that some of the geometrical dimensions characterising plant conditions may have changed. In a fluidised bed, for instance, the mean distance between various particles may have changed.

The non-dimensional groups appear as coefficients in the transformed equations, which are otherwise identical to their original equations. With the exception of the Mach number, they are represented by their reciprocal values.

The Strouhal number is related to all the time-dependent terms irrespective of the quantity to which they refer. It is evident that this non-dimensional group forms a useful criterion with respect to unsteady conditions. However, no investigations of outstanding importance have yet been published using this particular group. Any intended investigation applying frequency response methods should begin with a careful check on the significance of the Strouhal criterion, otherwise the results may be of doubtful value.

It is known that unsteady flow conditions may result in considerable deviations from steady flow features. Even if it is tried to keep flow conditions steady, and assuming that this can be achieved by varying systematically the composition of the test fluid, periodic changes in flow will occur at defined frequencies. A nitrogen/hydrogen mixture of changing composition may be applied. The considerable difference in viscosity under prevailing laminar conditions would result in flow fluctuations. Similar consideration should be taken into account when planning such investigations, as the

* The meaning of the model laws of dynamic similarity has been illustrated in many textbooks and papers. Reference should be made to some of the more important ones, e.g. Birkhoff[1]; Bridgman[5]; Duncan[6]; Focken[10]; Groat[11]; and Langhaar[13]. Some knowledge of the basic principles of dynamic similarity is required when studying the arguments of this article.

Table I

Equation of continuity :

$$(I) \qquad \frac{\partial \rho}{\partial t}+\frac{\partial(\rho u)}{\partial x}+\frac{\partial(\rho v)}{\partial y}+\frac{\partial(\rho w)}{\partial z}=0.$$

$$(T) \qquad \frac{l_1 f_1}{a_1}\frac{\partial \bar{\rho}}{\partial \bar{t}}+\frac{\partial(\bar{\rho}\bar{u})}{\partial \bar{x}}+\frac{\partial(\bar{\rho}\bar{v})}{\partial \bar{y}}+\frac{\partial(\bar{\rho}\bar{w})}{\partial \bar{z}}=0.$$

STROUHAL

Third Navier-Stokes equation :

$$(I) \qquad \frac{\partial w}{\partial t}+u\frac{\partial w}{\partial x}+\ldots=-\frac{1}{\rho}\frac{\partial p}{\partial z}-g+\ldots+2\frac{1}{\rho}\frac{\partial}{\partial z}\left(\mu\frac{\partial w}{\partial z}\right)+\ldots+\frac{1}{\rho}\frac{\partial}{\partial z}\left(\mu^{*}\frac{\partial w}{\partial z}\right)$$

$$(T) \qquad \frac{l_1 f_2}{a_1}\frac{\partial \bar{w}}{\partial \bar{t}}+\bar{u}\frac{\partial \bar{w}}{\partial \bar{x}}+\ldots=-\frac{p_1}{a_1^{2}\rho_1}\frac{1}{\bar{\rho}}\frac{\partial \bar{p}}{\partial \bar{z}}-\frac{g l_1}{a_1^{2}}+\ldots+2\frac{\mu_1}{a_1 l_1 \rho_1}\frac{1}{\bar{\rho}}\frac{\partial}{\partial \bar{z}}\left(\bar{\mu}\frac{\partial \bar{w}}{\partial \bar{z}}\right)+\ldots+\frac{\mu_1^{*}}{a_1 l_1 \rho_1}\frac{1}{\bar{\rho}}\frac{\partial}{\partial \bar{z}}\left(\bar{\mu}^{*}\frac{\partial \bar{w}}{\partial \bar{z}}\right)$$

STROUHAL FROUDE REYNOLDS REYNOLDS

Energy equation :

$$(I) \qquad c_v\frac{\partial \Theta}{\partial t}+c_v u\frac{\partial \Theta}{\partial x}+\ldots+p\frac{\partial}{\partial t}\left(\frac{1}{\rho}\right)+pu\frac{\partial}{\partial x}\left(\frac{1}{\rho}\right)+\ldots=\frac{\mu^{*}}{\rho}\left(\frac{\partial w}{\partial z}\right)^{2}+\ldots+2\frac{\mu}{\rho}\left(\frac{\partial w}{\partial z}\right)^{2}+\ldots+\frac{1}{\rho}\frac{\partial}{\partial x}\left(\lambda\frac{\partial \Theta}{\partial x}\right)+\ldots$$

$$(T) \qquad \frac{l_1 f_1}{a_1}\frac{\bar{c}_v}{\bar{c}_v}\frac{\partial \bar{\Theta}}{\partial \bar{t}}+\bar{c}_v\bar{u}\frac{\partial \bar{\Theta}}{\partial \bar{x}}+\ldots+\frac{l_1 f_1}{a_1}\frac{p_1}{\rho_1 c_{v1}\Theta_1}\bar{p}\frac{\partial}{\partial \bar{t}}\left(\frac{1}{\bar{\rho}}\right)+\frac{p_1}{c_{v1}c_{v1}\Theta_1}\bar{p}\bar{u}\frac{\partial}{\partial \bar{x}}\left(\frac{1}{\bar{\rho}}\right)+\ldots=\frac{\mu_1^{*}}{a_1 l_1 \rho_1}\cdot\frac{a_1^{2}}{c_{v1}\Theta_1}\cdot\frac{\bar{\mu}^{*}}{\bar{\rho}}\left(\frac{\partial \bar{w}}{\partial \bar{z}}\right)^{2}+\ldots+2\frac{\mu_1}{a_1 l_1 \rho_1}\cdot\frac{a_1^{2}}{c_{v1}\Theta_1}\cdot\frac{\bar{\mu}}{\bar{\rho}}\left(\frac{\partial \bar{w}}{\partial \bar{z}}\right)^{2}+\ldots+\gamma_1\frac{\lambda_1}{a_1 l_1 \rho_1 c_{v1}}\frac{1}{\bar{\rho}}\frac{\partial}{\partial \bar{x}}\left(\bar{\lambda}\frac{\partial \bar{\Theta}}{\partial \bar{x}}\right)+\ldots$$

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Equation of state :

$$(I) \qquad p=(c_p-c_v)\rho\Theta.$$

$$(T) \qquad \bar{p}=\bar{\rho}\bar{\Theta}.$$

Transformation rules :

Lengths : $\bar{x}=x/l_1,\ \bar{y}=y/l_1,\ \bar{z}=z/l_1$
Velocities : $\bar{u}=u/a_1,\ \bar{v}=v/a_1,\ \bar{w}=w/a_1$
Time, frequency : $\bar{t}=t/t_1, f_1=1/t_1$
Density : $\rho=\rho/\rho_1$
Pressure : $\bar{p}=p/p_1$
Temperature : $\bar{\Theta}=\Theta/\Theta_1$
Specific heats : $\bar{c}_v=c_v/c_{v1},\ \bar{c}_p=c_p/c_{v1},\ \gamma_1=c_{v1}/c_{v1}$
Viscosity : $\bar{\mu}=\mu/\mu_1$
Volume viscosity : $\bar{\mu}^{*}=\mu^{*}/\mu_1{}^{*}$
Heat conductivity : $\bar{\lambda}=\lambda/\lambda_1$

(I)—Initial equation
(T)—Transformed equation

Strouhal number is a crucial criterion of process plant dynamics.

The scheme of the transformed differential equations reveals furthermore that each non-dimensional group is related to coherent terms, and, therefore, can occur only in specific equations. It is a truism that besides the Strouhal number none of the other groups can be correlated to the equation of continuity.

The interpretation of the Navier-Stokes equations has led to some confusion. The first term on the right-hand side of the transformed equation, namely,

$$p_1/a_1^2\rho_1$$

represents, according to Oswatitsch, the Mach number. However, this is not correct, as the term mentioned represents a non-dimensional friction term. If the Navier-Stokes equations are not construed quite differently—if such a step will be permissible seems to be questionable—they could hardly be related to the Mach number. The appropriate term referring to the Mach number is included in the Energy equation, which should be obvious, as the velocity of sound is related to the ratio of specific heats, pressure and density. The Mach number itself is represented by the term

$$a_1^2/c_{v1}\Theta_1$$

which, by eliminating

$$\Theta_1 \text{ by } p_1/\rho_1(c_{p1}-c_{v1})$$

results in

$$\gamma_1(\gamma_1-1)M_a^2.$$

The term $(\gamma_1-1)M_a^2$ has been called the Eckert number in the English translation of H. Schlichting's well-known book on Boundary Layer Theory (translation by J. Kestin, 1955, London: Pergamon Press, Ltd.). There is no objection against the introduction of a dimensionless ratio of characteristic temperatures as a parameter value, which may be indeed a very useful term. But relating this term to the square of the Mach number is a procedure which is meaningless, as any dimensionless term could be related to a function of any non-dimensional group, which, however, has no physical significance. Operations of this kind are in contradiction to the axiomatic rules and in particular to the one referring to completeness as established in the present section.

Heat transfer problems should be related to the Péclet number. Some of the manipulations, which should be discarded, represent this true law of dynamic similarity by the product of the Reynolds number and the Prandtl number. For many gases the Prandtl number is a mere constant, which is not the case for liquids; therefore, its unrestricted use may lead to erroneous results.

In comparison with other methods of introducing non-dimensional groups the transformation of the basic differential equations is quite useful, but still may result in some ambiguity. Therefore, the Author[6] has presented a scheme, which is straightforward and based on simpler propositions. The scheme consists of a series of tables, which are designed on the basis of some axiomatic rules of formation.

In the first columns of Table II, main Tables 1 to 3, the basic magnitudes of mass, length and time are arranged consecutively with respect to integral powers of the magnitudes. The subsidiary Tables 1(*a*) and 2(*a*) contain only length and time, omitting mass. These tables characterising flow and heat transfer include all derived magnitudes of dynamics and dynamic properties of matter or qualities expressed in basic magnitudes. A sub-section of this article will deal with the completeness of this system.

One of the axioms is that the genuine, non-dimensional groups comprise at least a velocity term. Furthermore, length, density and specific heat may be included, which becomes evident from the second column. The terms in the second column are dimensionally equivalent to the corresponding terms of the first column. In the third column basic quantities of dynamics are given, each column being headed by a property like viscosity, surface tension, heat conductivity, frequency and acceleration of gravity. Table 1(*a*) forms an exception as it includes two non-dimensional groups, the velocity of sound being a dimensional equivalent to the velocity term.

Some authorities do not concede the necessity of using integral powers when establishing the basic quantities or qualities of dynamics. As all the magnitudes can be expressed by such terms, nevertheless it should be considered as a useful convention of Newtonian dynamics.[8, 9]

In some way the first scheme interconnecting the non-dimensional groups with specific terms of characteristic differential equations is certainly very useful to a better understanding of the physical significance of the various groups. On the other hand the scheme developed by the author[6] gives even greater emphasis to the uniqueness of each group. Occupying special places in the various tables indicates at least their interrelation with some specific, derived magnitude. It is quite important to stress this point, as the main thesis of the Author's investigation is that the true non-dimensional groups of dynamic similarity form entireties. This statement is particularly directed to restrictions of mathematical manipulations. Neither can the various terms forming integral parts of each group be uncritically interchanged, even by dimensionally equivalent terms, nor is it permissible to apply such simple mathematical operations, like addition, to various groups.

Both the Pi Theorem and another method introduced by B. F. Groat[11] have resulted in some misinterpretation, which may not have been intended by the originators. Groat generalises Newton's proposition XXXII (Theorem XXVI) referring to two similar systems of bodies, relating this proposition also to other groups like the Reynolds number. Groat (page 275) gives the following interpretation of this proposition.

"The term, 'accelerative force,' means the intensity of a force per unit mass acted upon by the force. The most common example is the acceleration of gravity, g, which is the acceleration of a freely falling body at the earth's surface. If this is multiplied by the measure of the mass acted upon, the result is the total force acting upon the mass.

"Hence, Newton's Law of Similarity supplies the fundamental equation of similitude, namely $g=V^2/D$, in which the symbols relate to ratios of homologues.

"Two systems of forces in space are dynamically similar if the lines of action of the forces (produced if necessary) form similar geometrical figures in space, while the measures of the two individuals of every pair of homologous forces in the two systems are in a fixed ratio (called the 'force ratio of the homology'). Thus it is clear that proportionality of homologous forces, and geometrical similarity of the figures formed by the systems of lines representing their magnitudes and loci, are both involved in the idea of dynamical similarity."

F. Eisner in a discussion (Groat[11]; pages 329 to 335) rightly pointed out that the Froude number is a result of Newton's proposition, but is not identical to it, otherwise it may be concluded that all groups of dynamic similarity are merely functions of the Froude number, which, of course, would make the complete system of groups meaningless.

Both the schemes, as presented here, should prevent misunderstandings which have arisen from the Pi Theorem and Groat's investigations. Plant dynamics should be based on non-dimensional groups, considering each pertinent group as a separate independent variable.

On the Completeness of the System of Non-Dimensional Groups.—The completeness of the set of non-dimensional groups, as evolved in the preceding section, is an important feature in all process plant investigations. Do the various groups suffice to analyse all dynamical properties of plant characteristics, does this system already include ambiguous terms, is it overdetermined, i.e. are there any guiding rules which exclude from the very beginning some terms from the complete set

TABLE II

TABLE 1

$M\,L^{-1}T^{-1}$	... vl/ρ	... Viscosity $=\mu$	$R_e=\frac{vl\rho}{\mu}$	Reynolds
$M\,L^{0}\,T^{-1}$	... $vl^2\rho$	... Mass rate of flow		
$M\,L\,T^{-1}$	... $vl^3\rho$	... Momentum		
$M\,L^{2}\,T^{-1}$	... $vl^4\rho$	... Action		

TABLE 1(*a*)

L^0T^{-1}	... vl^{-1}	... Frequency $=$	$S_r=\frac{vl^{-1}}{f}$	Strouhal
LT^{-1}	... vl^0	... Velocity of sound $=c$	$M_a=v/c$	Mach

TABLE 2

$M\,L^{-1}T^{-2}$	... $v^2l^2\rho$			
$M\,L^{0}\,T^{-2}$	... $v^2l\rho$	... Surface tension $=\sigma$	$W_e=\frac{v^2l\rho}{\sigma}$	Weber
$M\,L\,T^{-2}$	... $v^2l^3\rho$	... Force		
$M\,L^{2}\,T^{-2}$	... $v^2l^4\rho$	... Energy		

TABLE 2(*a*)

LT^{-2}	... v^2l^{-1}	.. Acceleration of gravity $=g$	$F_r=\frac{v^2l^{-1}}{g}$	Froude

TABLE 3

$M\,L^{-1}T^{-3}$	... $v^3l^{-1}\rho$			
$M\,L^{0}\,T^{-3}$	... $v^3l^0\rho$			
$M\,L\,T^{-3}$	... $v^3l[\theta^{-1}]$	... Heat conductivity $=\lambda$	$P_e=\frac{vl\rho c_p}{\lambda}$	Péclet
$M\,L^{2}\,T^{-3}$	... $v^3l^2\rho$	... Power		

of true non-dimensional groups of dynamic similarities? Answer to all those questions cannot be given with our present knowledge, which is particularly lacking a general axiomatic system on dimensions.† Nevertheless, an attempt will be made to establish some practical outlines in elucidating these questions, as far as possible and necessary within the limited scope of the present article. This investigation may help to settle some of the points which have arisen in many recent publications on process plant characteristics. A clear understanding of the meaning of completeness is of great practical importance. If it is agreed upon, that the set is complete, the remaining task is merely to present test results of experimental investigations on one or more of the groups readily available. This would be a step in advance and would prevent the urge of some authorities to introduce new groups.

The term "completeness" in connection with dimensional analysis is used with different meanings. Duncan[5] (page 8) refers to an interpretation of completeness due to Buckingham: "The great advantage of adopting a consistent set of units is that the equations representing symbolically the relations between the measures of the quantities which appear in any physical problem hold good quite irrespective of the choice of the fundamental units. Equations related to physical problems and which possess this property have been called *complete* by Buckingham. Incomplete equations are sometimes used by engineers but, although the equations may be valid in a particular field of application, they are not applicable universally."

H. L. Langhaar[18] (pages 17 and 18) postulates Buckingham's Theorem even in a more far reaching way, viz.:

"A sufficient condition that an equation be dimensionally homogeneous is that it be reducible to an equation among dimensionless products.

"If an equation is dimensionally homogeneous, it can be reduced to a relationship among a complete set of dimensionless products."

The scope of the meaning of "complete" is given by the following definition:

"A set of dimensionless products of given variables is complete, if each product in the set is independent of the others, and every other dimensionless product of the variables is a product of powers of dimensionless products in the set."

These definitions of completeness are not yet sufficiently stringent. They may result in terms which are either *dependent variables* or mere *parameter* values. This is clearly shown by an example given in Langhaar's book (pages 121 and 122). He includes, without any distinction, all the following groups in a complete set, viz. the Reynolds number, a pressure coefficient, the Froude, Mach, Weber, Grashof, Nusselt, Prandtl numbers, and a term designated by K (for which no name is given). The term K should be replaced by the Péclet number, which is only mentioned in the text and not specifically in the table. On the other hand the pressure coefficient and the Nusselt number are dependent variables. The Prandtl number, a parameter, is a mere ratio of properties of matter, viz. viscosity and heat conductivity. It is not a genuine group of dynamic similarity. The Grashof number does not correspond to the requirements of completeness as specified by Langhaar himself. This becomes evident as it may be either expressed by the product of an expansion term $\beta\theta$ and the square of the Reynolds number and/or the Froude number. As the Grashof number includes the square of the viscosity, Langhaar should have discarded it as a new model law, which he rightly did with a similar expression related to the square of the Reynolds number at the beginning of his book (page 17).

Another statement by Buckingham seems to clash with that which should be understood by "completeness." In accordance with Langhaar (page 38) there are infinitely many different complete sets of dimensionless products that can be formed from a given set of variables. In his version any complete set of dimensionless products is admissible. Following this argument, he says, that some sets of products are more useful, in practice, than others. Furthermore, better experimental control over dimensionless variables may be obtained if the original variables that can be regulated, each occur in only one dimensionless product. To quote once more Langhaar,

"If a velocity V is easily varied experimentally, then V should occur in only one of the independent dimensionless variables. That dimensionless variable can then be regulated by varying V. Likewise, if a pressure p can be easily varied without affecting V, then p should occur in only one of the independent dimensionless variables, but not in the same one as V."

"The dependent variable of the problem must also be considered. It is desired to know how this variable depends on the other variables. The dependent variable consequently should not occur in more than one dimensionless product. This product will be called the 'dependent dimensionless variable.'"

Very similar arguments have been presented by Duncan. As these outlines are closely related to the "Organisation of Experiments" and the choice and importance of the variables, as well as the critical distinction between independent and dependent variables, some qualification of these deliberations is wanted.

Although all of the groups developed in accordance with the two main schemes of the previous section include the velocity as a variable and integrating term, they are independent variables. Some of the groups include a length term as well as a density term, which is one of the axiomatic rules of formation of true non-dimensional groups. Nevertheless, they are all independent, therefore, the main argument should run on quite different lines in contradistinction to Duncan and Langhaar. Each group is distinguished by a certain property or quality, viscosity, surface tension, frequency, acceleration of gravity, &c., and none of those features should occur in another group. This criterion is essential for the establishment of the true groups of dynamic similarity.

As an example, the Weber number is correctly expressed, as follows:—

$$W_e = v^2 l \rho / \sigma.$$

Therefore, and in accordance with the last mentioned criterion, it is incorrect to include acceleration of gravity in the Weber number. Acceleration of gravity is the unique feature of the Froude number. Some authors present the Weber number by the following term:

$$\sigma / g l^2 \rho.$$

The definition of completeness, as preferred by the author,[8] is closely related with some clear outlines on the meaning of "independent variables." A complete set of non-dimensional groups of dynamic similarity comprises only those terms which are independent variables. Any statement like this is obviously meaningless if there are no corresponding terms which are the "dependent variables." To say that a Reynolds number is equal to 370,000 does not make any sense if it is not related to a certain plant or device and also to some process conditions.

The dependent variable may be characterised by a term which refers to frictional losses or some term presenting features of heat transfer. Such terms are, for instance, the Nusselt number or a friction coefficient, which are related to dissipation of energy. The author's thesis is, therefore, that the true non-dimensional groups are "independent variables," and as such entities they have only a meaning in the domain of irreversible or one-way processes.

These assumptions have certainly narrowed down the number of non-dimensional groups, which is an important step regarding their practical application. Unfortunately, the present tendency is to introduce non-dimensional groups without due considerations. Plant performance is characterised by terms which may occasionally fit test results to some empirical relationship, which hardly can be applied to other cases. Until some scheme of true non-dimensional groups has been generally accepted, the confusion will steadily increase. Some international agreement is, therefore, strongly recommended.[7]

Both the schemes of the previous section have established a restricted number of true laws of dynamic similarity. They are resulting in the same number of groups, with the exception of the Weber number for which no corresponding term was included in the differential equations. The differential equations are of comprehensive nature and have been used as a general description of flow and heat transfer phenomena. If, in the domain of both these fields unknown phenomena exist or should be discovered, some new term may arise which may lead to another group. However, this seems to be rather unlikely. On the other hand it may be pointed out that only recently the neglect of unsteady conditions has resulted, that the true significance of the Strouhal number was not recognised by most authorities. Similarly, one or another aspect may become predominant.

Another way of approach to define a complete set of non-dimensional groups could be based on an axiom, that the dynamic system of entities is characterised only by integral powers‡ (Fleischmann[9]) of the basic magnitudes of mass, length and time. Even when not accepting this axiom, it may be quite difficult to construe a comparable system including all terms of dynamics, which differ essentially from the one presented and which would establish further groups in addition to those already dealt with. Merely developing a system which is based on fractional powers for the sake of argument would obscure the issue, if it cannot evolve new and essential groups.

Summarising; a complete set of true non-dimensional groups of dynamic similarity may be defined by restricting the groups to independent variables. This pre-supposes one-way processes, which distinguish cause and effect.[8] Each group is related only to

† An interesting contribution is due to R. Fleischmann.[9] He showed that quantities and qualities of dynamics may be treated as Abelian groups. In view of the fact that the non-dimensional groups cannot be combined in accordance with the most simple rules of algebra, it seems to be a useless attempt to establish the laws of dynamic similarity on similar arguments as presented by Fleischmann. Such a formalistic way of approach could hardly reveal more than, for instance, the Pi Theorem.

‡ H. Dingle[4] (page 342) states that no fundamental significance can be claimed for a relationship which does not include fractional indices.
The term (T^{-2}) is according to Dingle just as meaningless as $(M^{\frac{1}{2}})$.

one quality. Qualities are dimensionally determined by a power of one unit smaller than the correlated quantity in a set of tables in which the various entities of dynamics are systematically arranged with basic magnitudes, mass, length and time. The number of terms in the table is limited, as degenerated qualities have no physical significance. Concluding this section it may be mentioned that completeness, as interpreted at length in this section, may differ in some respect from that term which is used when examining axiom systems of mathematics and logic.

On the Mathematical Manipulation of Non-Dimensional Groups

The mathematical manipulation of non-dimensional groups appears to be as confused as the interpretation of and operations with dimensions themselves. N. Campbell[3] observes that almost every proposition about dimensions asserted by one writer has been denied by a writer of equal competence. Diversity of opinion could be narrowed down to more acceptable terms by establishing a clear distinction between a mere mathematical relationship and a physical equation. An equation may be mathematically true but physically meaningless. An important criterion due to H. Dingle[4] is the necessity that a physical relation shall have a meaning. He refers to an example of adding magnitudes of length and those of time, which is not a physically significant one. Any equation is meaningless in which every term is not expressible in terms of the same magnitude. This consideration will be accepted as an important postulate.

Neither E. A. Guggenheim's[12] statement, "that we are entitled to multiply together any entities, provided our definition of multiplication is self-consistent and obeys the associative and distributive laws," nor G. Birkhoff's[1] remark, "The Pi Theorem is a mathematical theorem; hence (I say this for the benefit of physicists and engineers), it has absolute validity," are acceptable in the domain of non-dimensional groups of dynamic similarity. Operations of this kind give ambiguous results and may have no physical significance.

The problems related to the manipulation of non-dimensional groups are even more involved by the fact that the groups are pure numbers. However, to apply to those numbers the common rules of algebra would lead to serious confusion. The simplest mathematical operation of addition can be related to quantities (extensive terms), but not to qualities (intensive terms). The question arises whether addition is applicable to non-dimensional groups? Formally such an operation may be accepted as permissible; however, the following considerations will show that this is not the case, in spite of the fact that these groups are pure numbers.

A simple example which may be related to $R_e=10{,}000$ and $F_r=0{\cdot}9$ shows that a straightforward addition, resulting in a numerical value of 10,000·9 is physically meaningless. This figure of 10,000·9 does not reveal its origin any more. If a process is characterised both by a Reynolds number and a Froude number, any randomly chosen combination of numerical values can result in the same figure of 10,000·9.

Are values related only to one group, say the Mach number, additive? The Mach number equal to unity refers to a condition when the velocity of sound is reached. However, the addition:

$$1(1)_{M_a}+1(1)_{M_a}=2$$

has no physical significance. This operation is comparable to a statement that two liquids of the same density of unity when mixed would result in a density of 2.

Furthermore, the multiplication of two non-dimensional groups of dynamic similarity is in general not admissible. This statement is easily understood when referring to those groups which characterise flow conditions. It is known that both the critical Reynolds and critical Froude numbers are separating distinct regimes of flow. Suppose $R_eF_r=6000$. The flow conditions may be characterised by

$R_e=100{,}000$	(A)	...	...	...	$F_r=0{\cdot}06$	(a)
6,000	(A)	...	...	...	1·00	(b)
2,000	(B)	...	...	...	3·00	(c)
1,500	(C)	...	...	...	4·00	(c)

wherein (A) is related to turbulent flow and (B) is related to the critical or transient state (C) is related to laminar flow, (a) is turbulent flow, (b) is critical flow, (c) is rapid or shooting flow. Assuming the product of $R_eF_r=1000$, comparable values may be

$R_e=10{,}000$	(A)	...	...	...	$F_r=0{\cdot}10$	(a)
2,000	(B)	...	...	...	0·50	(a)
500	(C)	...	...	...	2·0	(c)

Both these examples were only given to indicate that the multiplication of two non-dimensional groups may result in an ambiguous product which does not indicate truly the regimes of flow and therefore present physically insignificant results. It should be noted that the numerical values of the larger Froude numbers may not be realised, or may be incompatible with the velocity term of the Reynolds number. The examples only indicate the fallacy of mathematical manipulations.

The main argument against the above-mentioned operations of addition and multiplication are that they lead to results which do not indicate any more the physical significance of the non-dimensional groups involved. This is due to the fact, that specific dynamic properties are correlated to the various numerical values of the non-dimensional groups. Furthermore, some of the groups form critical numbers separating various dynamic regimes.

It can be shown on similar outlines, that the multiplication with parameter values smaller than unity is not permissible, otherwise comparatively large values of the non-dimensional groups characterising conditions well within a predetermined regime may be mixed up with terms which are outside this particular regime. These short remarks may suffice to give a warning against uncritical mathematical manipulations of non-dimensional groups.

The interesting result of these deliberations, is the fact that the non-dimensional groups of dynamic similarity cannot be manipulated as pure numbers. They do not follow generally the usual rules of addition and multiplication. Whilst formally such and similar operations may be executed, the results will have no physical significance, they are meaningless and are false statements from the point of view of representing the laws of nature by mathematical relationship. This means that the non-dimensional groups form a distinct class of entities, which differs from quantities representing extensive magnitudes to which addition is applicable. Furthermore, they do differ from qualities or intensive magnitudes, in spite of the fact, that these form integral components of the groups. At least for some of the qualities "mixing rules" can be established, which may be considered as a kind of addition operation.

Why do not these numbers follow the usual rules of algebra? The reason for this is that any values, say, 2·5 or 700,000 have no meaning if they are not related to a specific non-dimensional group. 2·5 may be a Reynolds number, i.e. a very low one, but referring to a Mach number it is comparatively large. 700,000 is quite a common Reynolds number, but meaningless as a Mach number. However, the gist of these numerical values is more far-reaching. They have only a meaning if they are related to a specific phenomenon, a process plant or any dynamic feature. Even this co-ordination is not sufficient, as each numerical value of the non-dimensional group must be related to some coefficient, a dimensionless group of dependent variables or the like. As already stated, the groups of dynamic similarity are the independent variables correlated with some dependent variables, in accordance with irreversible processes. This explains why, in the domain of numbers related to non-dimensional groups, those numerical values cannot be dealt with like ordinary pure numbers. Each numerical value has attached to it, so to speak, its own label.

An inspection of the complete set of groups, as presented in Table II, discloses another restriction in the mathematical manipulation of the non-dimensional entities. The basic law of dynamic similarity requires constant numerical values of each of the various groups for establishing well defined similar conditions and a specific value of the dependent variable. Two of the integral components of each group (excepting the Mach number with regard to the length dimension), which can be varied, are the velocity and length terms. Keeping, for instance, the Reynolds number constant the velocity may be doubled, but the length scale halved. The tables reveal that all other groups with the exception of the Péclet number are incompatible with such procedures. This means that a phenomenon or a plant characteristic which is related to more than one of the groups will necessarily result in dissimilar dynamic behaviour. This is one of the main arguments for excluding most of the elementary mathematical operations.

The investigation presented in the previous paragraphs indicate that the basic operations of algebra are not applicable to non-dimensional groups. Any relationship which includes addition, multiplication and powers of such groups is, therefore, only a mere tool of calculation with no physical significance. To extend such empirical relationships to other plants or conditions requires a proof of the permissibility of such a procedure, even when the laws of dynamic similarity are fulfilled. Extrapolation of experimentally established relationships need even more careful consideration and interpretation. A reliable answer from experiments can only be established by varying the conditions in such a way that large ranges of the pertinent non-dimensional groups and all parameter values are covered.

From these considerations it follows, that with three groups characterising plant behaviour, it is essential to analyse and represent the dependent variable as a function of three independent variables, for instance by means of a four-dimensional representation. There may be ranges in which all the three variables are more or less of equal significance. Extending the investigation over large ranges of each of the variables may reveal other regimes in which only one of the groups is predominant. Systematic investigations of process plant behaviour on those lines are still badly lacking. Many authors have lumped the various non-dimensional groups together or have interrelated them by mathematical manipulations contradicting the above-given outlines. Therefore

the available information on this subject makes it rather cumbersome to disentangle the various influencing factors and to present them in a correct way. Further progress can obviously only be achieved, if each non-dimensional group of the complete set is defined regarding its integrating parts. At present there is no general agreement on those points.

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Gas Content of Steam and Boiler Feed Water

By W. B. BARTLEY* and E. MOULT*

THE gases in boiler feed water and its steam are said to be CO_2 and NH_3. Since the concentrations are very small, the determination by titration methods needs to be carefully done, and the problem of taking samples in such a way as to avoid dissolving further gas is difficult. As far as electrical power station instrumentation goes, the quantity of these gases has been inferred either by the pH value of the boiler feed water as a continuous record, or as the difference in conductivity of the steam condensate before and after degassing ; this last measurement is conventional (e.g. Evershed and Vignoles measurement of conductivity by the " Dionic " water purity meter in conjunction with a Straub degassing condenser).

The existence of heat exchangers between the CO_2 coolant and the low-pressure steam in nuclear power stations in modern times, causes the measurement of the gas content of the steam to have a new significance, as an indicator of leakage across the heat exchanger, and demands a continuous and reliable record of the CO_2 content of the steam. An investigation of the practical difficulties of the measurement has led us to carry out tests on a conventional power station of fairly recent design, and we were fortunate enough to obtain permission to work in the Brunswick Wharf power station in London. Although in the normal case the measurement of the CO_2 content of boiler feed water might prove to be of greater interest than its measurement in steam, the experiment was made on steam, because of the nuclear power station angle, with the aid of a Straub degassing condenser kindly lent by the power station. This involved working with CO_2 at a level alleged to be of the order 1 part CO_2 by weight in 10^8 parts water.

The system is simple enough with the aid of an infra-red gas analyser for CO_2 since a reliable continuous record can be so obtained working with volume concentrations in air of tens of parts in 10^6. The steam to be measured is condensed and reboiled in the degassing condenser, and the liberated gases are collected from the condenser atmosphere by scavenging the upper part of the column with a stream of CO_2-free air, and passing this continuously through the infra-red analyser.

The diagram (Fig. 1) shows the experimental arrangement. It will be seen that it is necessary to cool the scavenging air stream which issues from the degassing condenser, to prevent condensation in pipelines, and that this procedure results in the air stream to be measured containing the vapour pressure above the condensed water. The error resulting from the humidity level of the air is removed by making the CO_2 determination differential in the infra-red analyser, which is " double beam." For this purpose, a reference air stream which is also in contact with the condensed water, is passed through the other side of the double beam system and the response of the CO_2 recorder resulting from water vapour is automatically balanced out of the measurement. By means of a tap, immediate check of the balanced, or zero, condition of the analyser can be made by by-passing that part of the air circuit which passes through the degassing condenser. Owing to the fact that these degassing condensers tend to " bump " when at optimum

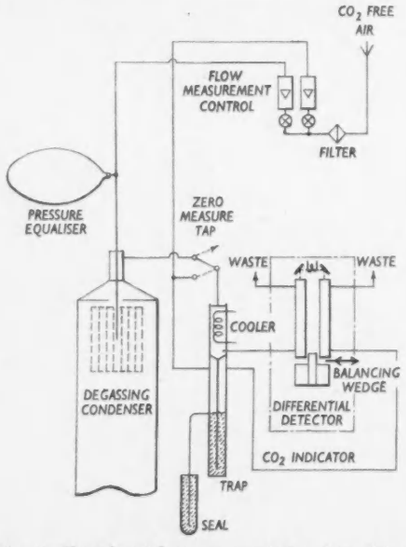


Fig. 1—Experimental arrangement for determining CO_2 content of power station steam

degassing adjustment, a rubber bag is used to smooth out pressure variations which prevent easy measurement of flow rate and may possibly break the water seals at extreme conditions.

The valuable property of the Straub degassing condenser which is used in these experiments is that a constant weight of condensate per unit time is produced. Thus, if the flow of scavenging air is also constant, there is direct proportion between the weight of CO_2 in the steam and the volume concentration in the air. In the condenser used here, the condensate amounts to 350 ml. per minute. If the CO_2 present is 1 part in 10,000,000 by weight, the amount liberated per minute is 350×10^{-7} grammes per minute, which is equivalent to $350\times10^{-7}\times22\cdot4/44$ litres per minute$=178\cdot10^{-7}$ litres per minute. Thus 1 part of CO_2 in 10^7 by weight is shown as approximately 18 p.p.m. by volume with scavenging at 1 litre per minute. The scale chosen for the analyser, a normal SB/K null-balance indicator, shown in the illustration (Fig. 2), was 0 to 100 p.p.m. CO_2.

In a power station with very good steam, the amount of CO_2 might be one order less

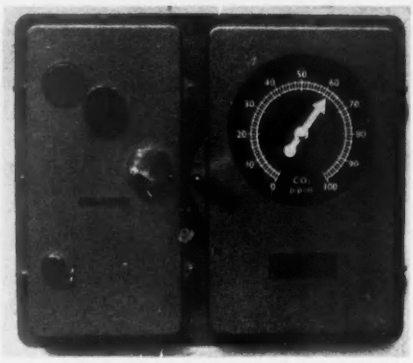


Fig. 2—SB/K null-balance indicator used in the experimental determination of the gas content of steam

than this, so that in this experiment a flow rate of 200 ml. per minute of scavenging air was used. Thus, 1 part of CO_2 by weight in 10^8 appears as $18\times10^{-1}\times1000/200$, or 9 p.p.m.

An advantage of the measurement itself is that the equipment can have a wide range of sensitivity. Since the flow rate of CO_2-free air determines the volume concentration read, and since the sensitivity of the infra-red analyser can be as high as 50 parts in 10^6 for full-scale deflection, it is possible to work conveniently with a full scale of 3 parts by weight of CO_2 in 10^8. This would correspond to a flow rate of 100 ml. per minute; but it would be quite convenient to use 3000 ml. per minute, thus giving a reduction in sensitivity of thirty times. Also, the infra-red analyser can be constructed conveniently with a second range of one-tenth of the sensitivity of the primary range, so that in all, the least sensitive full scale of the equipment could be approximately 1 part CO_2 by weight in 10^5.

The scale used in the Brunswick Wharf experiment was a linear one of 0 to 11 parts CO_2 by weight in 10^8 water. Some small problems in the scavenging air arrangement and the cooling of the gas had first to be solved, but the final stage was to carry out a continuous measurement over a period of forty-eight hours. Unfortunately, the infra-red gas analyser available was not fitted with a recorder, and so results were taken by a frequent reading of the indicator. Over the two days the CO_2 concentration varied approximately from 1·8 to 2·1 parts in 10^8, but no attempt was made to correlate values with any other condition in the power station.

The experiment of applying the method to determination of the CO_2 in the boiler feed water has not yet been carried out, but it will be clear that the only variation required is a satisfactory degassing unit.

We are grateful to the London Division of the Central Electricity Generating Board and Mr. J. R. Ambrose for allowing us to conduct this experiment at Brunswick Wharf power station. We also thank Mr. Duncombe for his practical help, and Mr. Crumley (Evershed and Vignoles, Ltd.) for his advice and assistance in the experiment.

* The Infra Red Development Company, Ltd., Welwyn Garden City, Herts.

Flexible Oil Barge

Work on the development of an idea for flexible barges began in 1956 and, after tank testing a small model, a larger unit was built and tested in inland waters and at sea. Based on the results obtained, " Dracone D.1," having a diameter of 5ft, a length of 100ft and a deadweight of about 40 tons, has been constructed and is now being demonstrated before undergoing a series of commercial trials.

IT was in the autumn of 1956 that Professor W. R. Hawthorne, Sir Geoffrey Taylor and Mr. J. C. S. Shaw, M.A., of Cambridge University, first considered the idea of flexible barges, and since then they have devoted considerable time towards solving the theoretical problems posed by floating a flexible skin, containing oil, in water. These problems were analysed and the static stresses evaluated and it was considered that these could be withstood by existing fabrics. With this as a starting point, a model of some 9in diameter and 16ft in length was made and both its drag and behaviour when towed were determined by tests in the ship tank at the National Physical Laboratory. Apart from questions of frictional resistance, it was noted that the model, with its length to breadth ratio of over 21 to 1, may snake in the water and that means must be evolved to prevent this.

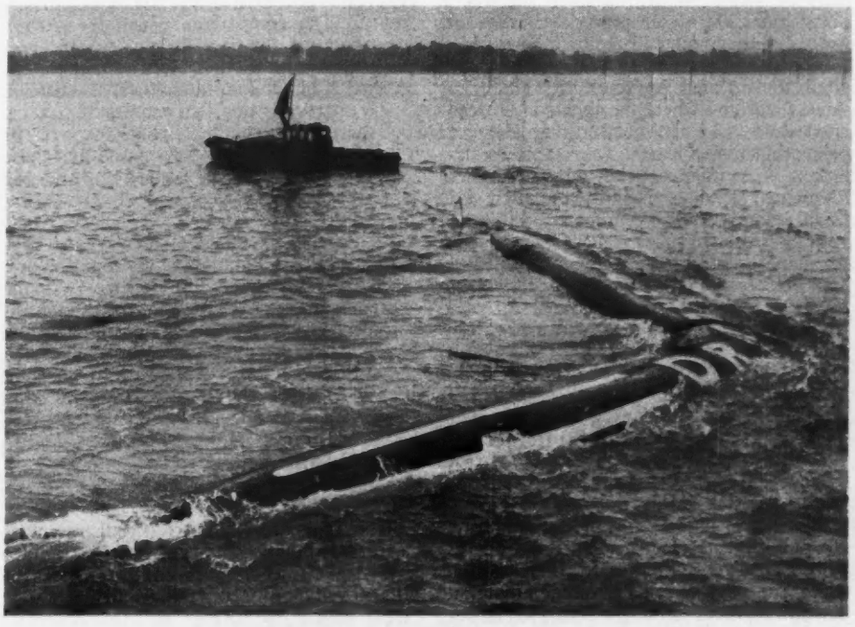
A larger model, 3ft diameter by 67ft long and having a capacity of 10 tons, was ready by the spring of the following year and successfully tested in the River Great Ouse. The results were sufficiently promising for the company, Dracone Developments, Ltd., to be formed and sponsored financially by the National Research Development Corporation, which was set up by the Board of Trade for the specific purpose of securing the development of inventions in the public interest. Early results were confirmed by additional trials in Harwich harbour and in the North Sea, when the model fulfilled predictions under a wide variety of weather conditions. The tests provided the opportunity to develop a method of preventing yawing and snaking at the cost of a small increase in drag, while it was found that ramming the bank at a speed of 5ft per second did no damage, the shock being taken by the nose and transferred to the fluid. Other trials showed that the model could be turned in less than its own length by forming a vertical fold which travelled lengthwise.

Research into constructional methods and the production of suitable skin materials resulted in the building of the first commercially operational " Dracone." This has a diameter of 5ft, a length of 100ft, and a capacity of 10,000 gallons and is constructed on the stressed skin principle, the skin being $^{5}/_{32}$in thick and consisting of a woven nylon fabric having each surface coated with synthetic rubber. Over 200 lb of fabric, which has a strength of approximately 600 lb per inch width, is used and provides the mechanical strength, while the remainder of the total weight of 2300 lb is accounted for by the rubber. This seals the fabric, is abrasion-resistant, and resists attack of oil or petrol cargo internally and of sea water and sunlight externally. The ends of the " Dracone " are faired, and towing and hose pipe connections are fitted at bow and stern, while eyes are fitted for attaching mooring ropes, buoys, floats and navigation lights. An Avery Hardoll self-sealing, quick-acting hose connection for filling and emptying through a 4in hose is fitted at the stern and there are also connections for measuring internal pressure.

When empty, the " Dracone " is wound on to a large floating reel, in the form of a squirrel cage 9ft long by 5ft in diameter, for the purposes of transport. If required, the " Dracone " can be folded into a packing-case for journey by air.

On Thursday of last week we witnessed some trials of the " Dracone D.1," which has been manufactured by P. B. Cow and Co., Ltd., and has been afloat for more than 500 hours. The cargo consisted of 10,400 gallons of kerosene of 0·796 specific gravity and weighing 37 tons, which completely filled the barge, leaving no air space. This latter is an essential condition, particularly with regard to avoiding any risk of fire. A 60 h.p. launch towed the barge, which had a freeboard of about 10in, at speeds ranging up to 5½ knots and carried out a number of turns which demonstrated how the " Dracone " kinks to follow the course of the launch and, hence, its manœuvrability. Our illustration is of the flexible barge being turned and shows the kink which is formed in the skin. The barge was boarded from a dinghy and later the cargo was pumped into a coastal tanker, using the non-spill Avery Hardoll connector, and the barge reeled up on to a floating reel. The partly unloaded barge can be seen in our illustration being rolled on to a floating reel. While this operation was under way the opportunity was taken to view a small exhibition which included the first model of 9in diameter and 16ft long, and also " Draconella," a model 3ft in diameter and 67ft long which weighs 200 lb and carried 10 tons of alcohol during research tests performed by the Engineering Laboratory at Cambridge.

Partly unloaded barge being rolled on to floating reel



Turning trials showing the manœuvrability of " Dracone D.1 "

It is understood that the skin of " Dracone D.1 " has a bursting stress of about 25 lb per square inch, a figure which is considered to provide an adequate margin of safety to meet the head set up by towing through waves and causing undulation. This dynamic head is considered to be approximately five times the static head as measured by the wave height.

Development work is continuing, and it is hoped to commence trials using the barge commercially under natural conditions in inland waterways. Trials at sea, which will be fully instrumented, are also planned to take place at an early date, while research into the behaviour among waves has been put in hand already. Furthermore, in anticipation of commercial developments, a manufacturing schedule for " Dracones " of the size seen on trial has been prepared and a second model is now under construction. From the economic standpoint, it is felt that the units are suitable for the transport of liquids lighter than water, since only low towing power is required, and they can be returned easily by road, rail, sea or air. Further, there is reason to believe that the capital involved and the operating costs will be considerably lower than conventional

barges, particularly since the deadweight is a very high proportion of the displacement, and the units will have a high ratio of availability. However, in considering the capital cost, it must be taken into account that the present design life is five years, although this may be greatly extended.

Future development includes a "Dracone" to carry 300 tons, for which plans are in hand, the woven nylon fabric for the skin having a strength of 2000 lb per inch width, while a larger unit of 1100 tons deadweight is also envisaged. The accompanying table gives provisional data for three sizes of "Dracones," the specific gravity of the cargo being assumed as 0·85.

"Dracone" Data

Diameter, feet	5	10	15
Length, feet	100	200	300
Capacity :			
Imperial gallons	10,000	75,000	270,000
Tons	40	300	1,100
Draught :			
Maximum, feet	4	8	12
Normal, feet	3·5	7	10·5
Maximum economical speed, knots	7	10	12
Drag :			
At economical speed, pounds	800	6,000	19,000
At 7 knots, pounds	800	2,000	3,500
Weight empty, tons	1	4	8

The Montreal Power Conference

No. I

The World Power Conference held a sectional meeting in Montreal from September 7 to 11. The meeting was characteristically international in character and was attended by over 1000 delegates ; its theme was "economic trends in the production, transportation and utilisation of fuel and energy." Here a brief account is given of the scope of the technical work of the conference, and the first major section of that work, which was devoted to hydro-electric engineering, is reviewed.

LAST week we published in our leader columns some comments on the Canadian sectional meeting of the World Power Conference, which was held in Montreal from September 7 to September 11. Here we review briefly the technical work of the conference, touching on each of the main subject headings into which it was divided. The general theme of the conference was "economic trends in the production, transportation and utilisation of fuel and energy."

The organisation of the discussions followed the usual practice for these conferences. The papers in each group were reviewed in a general report, and the general reporter introduced and summed up the discussion. The papers were grouped as follows :—

Section A : Production of Hydraulic Energy. A1, System Planning (thirteen papers) ; A2, Design and Operation (seven papers) ; A3, General (thirteen papers).
Section B : Production : Thermal Energy. B1, Coal (twelve papers) ; B2, Oil and Gaseous Fuels (thirteen papers) ; B3, Nuclear Energy and Nuclear Fuel (twelve papers) ; B4, Generation, Conventional Fuels (System Planning) (fifteen papers) ; B5, Generation, Conventional Fuels (Design and Operation) (six papers).
Section C : Production ; Other Sources (two papers).
Section D : Transportation : Electric Transmission (ten papers).
Section E : Transportation : Rail, Water, &c. (five papers).
Section F : Transportation : Pipeline (four papers).
Section G : Utilisation : Industry and Commerce (eighteen papers).
Section H : Utilisation : Farm and Residential (ten papers).
Section I : Utilisation : Transportation (four papers).
Section J : Utilisation : Utility Financing and Tariffs (three papers).

The three subdivisions of Section A were discussed on Monday, September 8, together with Sections B5 and C. The remainder of Section B was discussed on the Tuesday, "Transportation" on the Wednesday morning, and "Utilisation" on the Wednesday afternoon, and the following morning. An opening session was held on Sunday, September 7, and a closing session on the Thursday afternoon. There was a full programme of social events in the evenings, and of ladies' outings and visits to neighbouring sites of engineering construction during the days that the conference was in session. Post-conference tours, lasting from one to four days, were undertaken by many of the delegates.

In the ensuing description, Sections B4 and B5, which overlapped to some extent, have been grouped together. The Sections D, E and F relate to the transport of fuel, it may be mentioned, whereas Section I relates to the utilisation of fuel in the industry of transport.

Hydro-Electric Power

The three subdivisions of Section A included thirty-three papers, so the various aspects of hydro-electric generation received more emphasis than any other topic before the conference. In the first session, the tone of the discussion was set by the general reporter who suggested for discussion (1) how should the development of a country's hydraulic potential be planned so that the less economic sites are developed along with the more economic ones ? (2) how should hydraulic, thermal and nuclear plants be fitted into an overall plan to supply a growing load economically ? (3) what amount of over-development of hydraulic resources is economically justified in a mixed hydro-thermal system ? and (4) how can the economic advantages of pumped storage be clearly demonstrated ?

In countries where the load demand is outstripping the water power resources, the general tendency is to employ a lower load factor and correspondingly more powerful plant for selected hydro-electric stations—that is stations where the flow can be regulated—and to let thermal stations take over part of the base load. The emphasis thus placed on storage can be judged from the following figures, given during the discussion. G. Bardon (France) compared values of various classes of energy given in various of the paper as follows : base hydro-electric, 6500 hours use, 1 ; hydro-electric energy from schemes with weekly storage 1·5 ; and from alpine schemes with seasonal storage 2·5 to 2·7 ; peak energy about 1000 hours use, 3 to 3·5. C. Marcello (Italy) concluded that peak energy was worth three times base energy ; day energy was worth twice night energy ; winter energy was worth three times summer energy ; and energy from seasonal storage was worth four times run-of-river energy, at least for Italy.

A radically different solution was however set out by T. Ingledow (Canada) who described a power system in British Columbia. Here, run-of-river schemes predominate and the power which can be generated for most of the time is considerably in excess of the dependable capacity for the minimum month of the year, and for the minimum year over a ten-year period, these minima dictating the "firm" power. This secondary energy is being "firmed up," as the author expressed it, by installing two peak-load gas turbine power stations. A completely unattended station of 100MW capacity is due to go into operation this year at Port Mann in British Columbia. Four 25MW gas turbine sets are installed in this station, and it is considered that they offer substantial economic gain, as compared with conventional steam plant, for duty of this kind.

Many other examples were given of the integration of plants of different kind in the power systems of various countries. One of the factors stressed in the discussion was the importance of interconnection, and two papers (both in French) explored analytical approaches to system planning.

Pumped Storage

The foregoing considerations of the changing role which hydro-electric power is likely to play in many power systems also drew attention to the value of pumped storage. Here again, the advent of nuclear power is a major factor encouraging pumped storage schemes. The Blaenau Ffestiniog pumped storage scheme in Wales was described in a paper by Booth and Kennedy, and the economic criteria of its design were discussed. The differential costs of generation incurred in the system as a whole with pumped storage installed as an alternative to an equivalent capacity of new coal-fired base load plant were compared. The financial advantage of the pumped storage scheme was due mainly to its lower capital charges, it was pointed out, and, to a lesser extent, to savings accruing from the replacement of coal-fired plant for emergency duty. These savings will be partially offset by the loss of coal cost savings which would have been secured by the installation of the alternative high merit coal-fired plant, though this factor will decrease in importance throughout the life of the scheme.

An economic appraisal of the first peak-load pumped storage scheme in North America, the Ontario Hydro-Electric Power Commission's scheme at Niagrara, was also given, in a paper by M. Ward. The economic background here is entirely different, and is governed by the Niagara diversion treaty. The comparison which the author gave between the costs of this scheme and an alternative thermal-electric installation showed a 33 per cent saving over the latter.

An interesting problem arose in ascertaining the capacity of the storage reservoir of this scheme, and the paper showed that there was no economic justification for increasing the storage by 5000 acre feet (the useful capacity is 15,500 acre feet). The storage now available is sufficient to meet the day-time peak load by pumping the night before, in the early years of the scheme. As the system loads grow the function of the pumped storage scheme will tend towards meeting short-period peaks in the system, since the night-time load will then have grown sufficiently to utilise the full night-time diversion of water in the Niagara power stations and the need for transferring energy from night to day will have disappeared.

Hydraulic Machinery

The Niagara pumped storage scheme attracted interest, however, not so much by its general conception and design as by the novelty of its pumping and generating sets, which are driven by the reversible Deriaz pump/turbine. This machine was

first described at the Vienna conference and has been described in these columns on two occasions (THE ENGINEER, July 6, 1956, page 13, and January 17, 1958, page 106). The economic advantages claimed for it were expounded at the conference in a paper by P. Deriaz and J. G. Warnock. These authors drew attention to the "flattening" of the efficiency curve of a Francis machine by the introduction of variable pitch blades, thus giving a higher efficiency over a wider range of loads, just as the Kaplan turbine has a flatter curve than a fixed-blade propeller turbine. The first machines at Niagara were installed about a year ago, and the authors stated that anticipated performance had been achieved, and expressed optimism about the future—"the versatility and flexibility of performance which characterise this machine, will, it is believed, show better overall economic performance than was anticipated from the original studies using the limited duty cycles of more classical machines." The upper limit of head for the Deriaz pump/turbine has not yet been ascertained, and will depend on development work; during the discussion at the conference, Mr. Deriaz showed a drawing of a machine of 100,000 h.p. for operation in the 200ft to 240ft range of heads.

The United States is also to have a pumped storage scheme on its side of the Niagara River, and here, we understand, reversible pump/turbines will also be installed, but they will be fixed-blade Francis machines. The line of development here follows the machine of this kind already installed at Hiwassee, one of the T.V.A.'s plants, and at the Flat Iron plant of the Bureau of Reclamation. It is claimed for this type of machine that it has proved satisfactory in performance, and the simplicity of its design and operation is an economic incentive to the development of pumped storage.

One other development of this kind was reported in some detail at the conference, namely, the use of a multi-stage centrifugal machine as either a pump or a turbine. A paper by the Swiss author Lavanchy describes this work, which included the measurement of efficiency curves for the three-stage, double-flow pump of 10MW capacity installed at Pragnères, in the Pyrenées, operating as a pump and as a turbine. Considerable advantage is expected from the development of such multi-stage pump/turbine machines, which may run at two speeds, according to the mode of operation.

Several other important developments in the design of hydraulic turbines were reported. Nilsson, of Sweden, gave details of the large machines, claimed to be the largest in the world, now in operation at the Stornorrfors station. Three 130MW generating sets are installed. Each turbine operates under a head of 73m and with a nominal flow of 200 cumecs; the maximum output is 10 per cent above the rated figure of 130MW, and each turbine is a Francis machine with a stainless steel welded runner. The use of new alloys for turbines was also discussed, particularly the use of high-tensile steel for the stressed plate steel components of a hydro-electric station, and the use of stainless steel to reduce maintenance.

The so-called "bulb" or "tubular" turbines also attracted interest. An economic assessment of the development of a tidal power project was given by the French author R. Gibrat, who described the Rance scheme by way of illustrating his arguments. He stressed that a constant power output was not the aim of the scheme, but rather the achievement of an overall economic plan, which depended on the market for electrical power and in which peak load power, guaranteed power output, and annual production of power were the critical terms. The eight basic stages of the plant made possible theoretically 3×10^{32} different cycles of operation over a two-week period. The design of the horizontal-shaft "bulb" generating sets was sufficiently flexible to vary the operation as the overall economic appraisal dictated. The Swiss author Pfenninger described a "tubular" turbine—that is, a horizontal shaft machine with a submerged generator upstream of the turbine—as built twenty years ago and as developed to-day.

(*To be continued*)

Molybdenum Disilicide for High Temperature Sliding

By G. W. ROWE

THE lubrication of surfaces at high temperatures is nowadays of considerable importance. Low friction is usually desirable, but for many technical applications it is more important to prevent seizure, which may seriously damage expensive materials and equipment, than it is merely to save power by reducing friction. Oxidation resistance may also be a major factor. Molybdenum has a high melting point (2600 deg. Cent.) and is thus potentially useful as a high-temperature metal, but it oxidises rapidly in air. In vacuum or inert atmosphere the friction of clean molybdenum is high even at room temperature, and at elevated temperatures complete seizure occurs. It has been shown that good lubrication can be obtained *in vacuo* by depositing a film of molybdenum disulphide on the surfaces (Bowden, F. P. and Rowe, G.W., THE ENGINEER, November 8, 1957). Such films are effective at temperatures up to 800 deg. Cent. *in vacuo*, or preferably in hydrogen sulphide gas, but they oxidise rapidly at a moderate temperature in air.

It is well known that molybdenum can be protected from oxidation by a molybdenum silicide coating, which permits molybdenum filaments to be used in air at temperatures up to 1700 deg. Cent. The present experiments were conducted with sintered $MoSi_2$ bars supplied by the Climax Molybdenum Company, and with $MoSi_2$ coatings formed on pure molybdenum by vapour deposition (Beidler, E. A., Powell, C. F., Campbell, I. E. and Yntema, L. F., *Journal Electrochem. Soc.* 98, 1951, page 21). To establish reproducible conditions the sintered bars were first heated to 1100 deg. Cent. in a high vacuum (10^{-3} microns). When the specimens were cooled to room temperature it was found that, in contrast to the behaviour of metals, the friction of molybdenum disilicide was not very greatly influenced by this outgassing treatment. The coefficient of friction was $\mu = 0{\cdot}7$, which may be compared with that of clean molybdenum $\mu = 2{\cdot}0$, or of outgassed graphite $\mu = 0{\cdot}6$, under the same conditions. The friction was unaffected by the presence or absence of oxygen, water vapour and fatty acid vapour, and remained roughly constant as the temperature was raised to about 700 deg. Cent., either in high vacuum or in air. At higher temperatures the material becomes more ductile and a higher friction was recorded, reaching $\mu = 1{\cdot}4$ at 1100 deg. Cent. in vacuo, but seizure still did not occur. At about 900 deg. Cent. in air a change in the friction occurred, probably due to formation of a skin of silica on the molybdenum disilicide. The friction rose rapidly with temperature above 950 deg. Cent. and at 1100 deg. Cent. it was about $\mu = 1{\cdot}2$ but again seizure was avoided and no serious damage could be seen in the sliding track. Prolonged sliding at 1000 deg. Cent. in both directions over the track reduced the friction considerably.

The specimens for the coating experiment were two rods of spectroscopically standardised molybdenum. These were first outgassed and showed the usual high friction at room temperature. They were then heated to various temperatures in a stream of silicon tetrachloride and hydrogen to form a silicide coating. (Beidler, E. A., Powell, C. F., Campbell, I. E. and Yntema, L. F., loc. cit.) A thick coating was formed after heating to 1060 deg. Cent. for one hour but protective coatings could be formed at temperatures as low as 750 deg. Cent., probably because of the active nature of the cleaned molybdenum surface. The friction measured at room temperature after treatment at 1060 deg. Cent. was $\mu = 0{\cdot}80$. It has been reported (Powell, C. F., Campbell, I. E. and Gonser, B. W., "Vapour Plating," John Wiley, 1955, page 125), that more uniform coatings are obtained by a diffusion process which occurs if the specimens are heated in hydrogen at 1100 deg. Cent. This treatment had some effect on the friction, which was reduced to $\mu = 0{\cdot}62$. When the specimens were exposed to the air the friction was found to be $\mu = 0{\cdot}66$, and this value remained sensibly unchanged as the specimens were heated in air at various temperatures up to 700 deg. Cent. Above this temperature the friction rose rapidly.

These experiments suggest that $MoSi_2$ does not itself seize during sliding at high temperatures but maintains a steady though rather high friction. It is not seriously damaged by high temperature sliding. Films of $MoSi_2$ can protect molybdenum sliders from seizure and from oxidation so that sliding is quite feasible at temperatures up to 700–800 deg. Cent. in vacuum or in air. The coating is self-protective in air since a thin film of silica forms rapidly if the coating is damaged. Indeed, it is found that the friction actually falls slightly as sliding proceeds.

The anti-seizure property of these coatings, combined with their oxidation resistance, may be valuable for moving parts inside furnaces and also for hot-working tools. Since molybdenum disilicide is not attacked by liquid sodium the coatings may also be of use in high temperature heat-transfer systems.

I should like to thank the chairman of Tube Investments, Ltd. for permission to publish these results.

LETTERS AND LITERATURE

RAILWAYS INTO ROADWAYS

SIR,—Your correspondent, J. E. Allen (September 12), has raised some points which should not remain unanswered. It is conceded that the rolling resistance of a pneumatic tyre on a modern road surface is slightly less than twice that of steel on steel, but this disadvantage is more than counterbalanced by the fact that the dead load/payload ratio is even greater. A passenger train, including the prime mover, weighs approximately 1 ton per passenger seat, while a motor-coach weighs approximately 5 cwt per passenger. Again, the average goods train weighs well over twice its payload, while the modern heavy lorry often carries twice its own weight. I understand that all the main roads in the country (the "A" roads) are a direct Ministry responsibility and therefore the rates do not contribute to their upkeep. It is a strange argument, indeed, therefore, to suggest that road vehicles are not paying their whack when the cost of petrol and Derv is half tax, while a large proportion of the licence revenue goes to the general exchequer.

No ; the underlying reasons why B.R. are finding it increasingly difficult to compete are, in the writer's view, the following :

(1) The cost of maintenance of a modern road, once laid, is something of the order of one-tenth that of an equivalent railway track, on top of which the manning of all the signal-boxes twenty-four hours a day is far higher than the policing of an equivalent road system.

(2) Owing to the small size of this country, the average haul is only 50 miles or so and it is, therefore, almost ludicrous to collect at one end and deliver at the other, goods which could be delivered direct. Even with a commodity like coal, ideally suited to bulk transport, it is interesting to note that the gas industry reluctantly admits that 3,500,000 tons of coal is now delivered to gas works by road "because they are forced to seek reductions in costs." The great development of piggy-back systems in North America proves that for long hauls the railways still have advantages, but it has been found that the system is uneconomic below 300 miles, which puts it out of court for this country. British Road Services are continually taking traffic away from rail and, ironically enough, their very satisfactory profits are providing revenue to the State and (being owned by the B.T.C.) are significantly reducing the deficits of that organisation !

Modernisation of the railways will not be a solution, for a small country like ours. The French railway system is a living example of this contention. With massive American help, the system has already been largely modernised and I think all would agree that it is a very fine system. However, the cold fact remains that for 1957, with a straight subsidy of £90,000,000, it "earned" a deficit of £23,000,000 !

(3) With a rising standard of living and a greater distribution of wealth, an ever higher proportion of the population will reach the stage where it wishes to acquire its own means of transport. However much the present owners of motor vehicles may deplore this development, it is an undoubted fact and we cannot put the clock back.

At the present time, taking both goods and individuals into account, the railways are carrying from one-quarter to one-seventh of the total transport of the country, the wide variation in the estimates resulting from the point of view of the investigators ! It is clear that in future we shall become increasingly short of road routes, while virtually sterilising a superb ready-made system of routes on which we shall have spent £1500 million for carrying one-seventh of the transport of the country !

A word on imported fuel supplies. The modernisation programme of the railways is largely based on dieselisation, so we shall be in the same position whether we keep the railways or not. London Transport is about to embark on converting their silent, fumeless, trolley-bus routes to diesel buses, a highly dubious procedure, from the public point of view, but nobody seems to care, and economics has forced the issue. Why should railway electrification prove any more economic ? If tax on home-produced motor fuel was reduced and the processing of small coal, now in over-supply, into gas and liquid fuel encouraged thereby, we could build up a useful addition to our imported supplies. I need hardly say that I could not agree more with Mr. Allen's last suggestion.

D. F. C. VOSPER

Llandovery,
September 15, 1958.

SIR,—I should be reluctant to use the figures about rush-hour traffic at London Bridge, which you were so good as to publish in your issue of August 29, to deduce the seating capacity of all the down trains using that station in the twenty-four hours of a normal weekday. Based on recorded observations the seating capacity of the eighty-six trains calling at, or starting from, London Bridge in the peak hour, 5.0 to 5.59 p.m., is about 70,700, equal to 1768 forty-seater motor coaches running at two-second intervals.

It is often assumed that every rush-hour train is packed, but actually there are considerable differences between various services, between trains on those services, and even in the trains themselves. It is not unusual to see trains lightly loaded in front, well loaded in the middle, and packed in the rear, due largely to passengers allowing themselves only the narrowest margin of time in which to catch their train.

I used London Bridge as a daily traveller for over thirty years. I never had any reason to complain of the service or the accommodation, and although that terminus may not be ideal it always seemed to me to fulfil its purpose well enough. Two familiar trains on my homeward journey were those now leaving at 5.2 p.m. for Eastbourne and Seaford, and 5.5 p.m. for Littlehampton via Hove, both booked to run fast to Haywards Heath (37¾ miles) in forty-three minutes. Both are twelve corridor formations of "express" stock with toilet and refreshment facilities, providing 1234 seats. I imagine that a convoy of thirty-one motor coaches running non-stop to Haywards Heath at 52 miles an hour would be a very interesting sight.

G. T. MOODY

Tulse Hill,
September 18, 1958.

SIR,—I hesitate to throw my trivial two-penn'orth into such a discussion as this has now become, but there are figures in Brigadier Lloyd's letter in your issue of September 12, which I cannot reconcile, and I would be glad to have the missing factors pointed out to me.

The difficulty lies in the statement that 17,000 vehicles per hour could operate on a ten-lane road. If some of the lanes were two-way, this peak could be carried by, say, six ; i.e. : 2833 vehieles per hour, per lane. This involves a time-interval of 1·27 seconds, and a distance-interval of $1{\cdot}27v$ft, at $v$ft per second.

This distance-interval is also composed of :

(i) The length of the coach, 36ft.

(ii) The "reaction" distance, 0·4 secs at $v$ft/sec.

(iii) The braking distance $\frac{v^2}{2f}$ or $\frac{v^2}{50}$ at 78 per cent efficiency.

Hence we have :

$$1{\cdot}27v = 36 + 0{\cdot}4v + \frac{v^2}{50} \quad . \quad . \quad (1a)$$

Transposing, and tidying-up, we have :

$$0{\cdot}02v^2 - 0{\cdot}87v + 36 = 0 \quad . \quad . \quad (1b)$$

The roots of this equation being imaginary, the specified conditions are impossible in practice. The proposed flow-density conflicts with the safety limits.

By a simple differentiation, we see that the maximum safe flow attainable is 10,335 vehicles per hour on the six lanes, this being a time-interval of 2·09 seconds, at a speed of 42·43ft per second (28·9 m.p.h.). The clearance, nose to tail, would be 53ft !

We seem to have confirmed Mr. Dahl's contention, in the same issue, that the full benefits can only be realised when the vehicles are coupled and guided.

F. DORMAN BYERS,
B.Sc., A.M.I.Mech.E., M.I.N.

Clacton-on-Sea,
September 18, 1958.

RAILWAYS INTO ROADWAYS

The discussion in this correspondence has come full-circle round. Points are being raised by new correspondents which were raised some weeks ago by others. No further correspondence will be published unless we are satisfied a materially new point is being made.—ED., THE E.

Book Reviews

Electric Cranes : Their Design, Construction and Operation. By H. H. BROUGHTON. E. and F. N. Spon, 15, Bedford Street, London, W.C.2. Price £7 10s.

THIS is the third edition of a work by Mr. Broughton which is probably the most comprehensive treatise on cranes published in any language. The first eighteen chapters review in detail the underlying principles and current practice, both in Britain and abroad, of the design of component parts of cranes, such as the structure, hooks, ropes, mechanical transmission and other details. There are five chapters on electrical equipment in which the various systems of driving and control are given comprehensive treatment, and following these are six chapters covering methods of power calculation, general descriptions of many different types of cranes, and there is a final chapter on safety regulations. At the end of each chapter there is an extensive biography which is indicative of the wide research made by the author on all matters relating to crane design.

In the introductory chapters the book makes mention of many standard specifications—British, American and German—but unaccountably omits the only British Specification for Heavy Duty Steelworks Cranes which was first published in 1950 by the British Iron and Steel Research Association in collaboration with the Association of Cranemakers. A second edition has been published and this is the basis of design for most of the steelworks cranes made in this country. In chapter 2, dealing with structural materials and stresses, reference is made to the use of light alloys for girders and other structures, and whilst the author quotes both the tensile strength and modulus of elasticity of these alloys, it would have been advisable to draw attention to the necessity of making provision in the design for the greater deflection of structures composed of these materials compared with those constructed from steel. This is a feature which could be easily overlooked by a designer not alert to the necessity of keeping deflection of crane structures to a minimum as they so often form the support for machinery which must be kept in reasonable alignment.

Chapter 13 deals somewhat extensively with tracks, rail wheels and trucks and reference is made to what is described as a recent development of the flangeless runner with horizontal rollers to prevent the crane from skewing. This has been used as an expedient for the past forty years where gantries have got out of alignment or the wheelbase of the crane has proved too short. It is not a construction to be advocated for new installations. Reference is also made to taper tread wheels which, again, are only an expedient, and experience has proved that a rigid and properly aligned crane with adequate wheelbase and parallel tread wheels running upon a well-made crane track will prove more efficient and economical in upkeep than any other system.

In referring to brakes in chapter 16, it appears that the author was not aware of the extensive use of high tensile irons for brake sheaves which give far better results than other materials used in the past. Where strength considerations call for cast steel sheaves, these should be polished and surface hardened, otherwise trouble will result from abrasion. In the same chapter, the author states : " Hydraulic operation of the hoisting motion is a favoured method of extra high-speed lowering," but he does not state why or give any description of this method. However, in chapter 17 reference is made to a rapid lowering device used by a German firm, and it should be noted that an almost similar device was put into use by a British firm about thirty years ago. The book gives credit to Continental firms for the development of planetary gear devices and does not appear to have been aware of the use of this system on the " Temperley " grab transporter designed about fifty years ago and applied for grabbing duty and speed control to the present day. There is a tendency in the book to quote examples from American and Continental sources rather than from British, and whilst the author quite rightly has cast his net far and wide for information and examples of crane construction, it is unfortunate that examples from British practice are not more fully documented, but this might possibly be the fault of the British makers in not being more co-operative.

The tower crane illustrated on page 426 is a somewhat obsolete design, and capacities of these cranes have now been increased to 60 tons and not 35 tons as stated by the author. However, to compile a book of this nature is a long task and development can easily take place between the preparation of the manuscript and the actual publication, so that some latitude or time lag must be allowed to the author. There is no reference in the book to special steelworks cranes or to mobile cranes which now form such an important contribution to the crane industry and in which British manufacturers lead the world.

Mr. Broughton, who died soon after the publication of his book, has created a monument to his ability and thoroughness which will be a standard source of reference for crane users and designers for many years to come.

Etude expérimentale de l'ecoulement turbulent dans un divergent bidimensionnel parcouru par de l'air. By JEAN-PIERRE MILLIAT. Publications Scientifiques et Techniques du Ministère de l'Air, No. 335. Service de Documentation et d'Information Technique de l'Aéronautique, Magasin C.T.O., 2, Avenue de la Porte-d'Issy, Paris (15e). Price Ffr.2000.

THE present work is an experimental study of turbulent flow in a two-dimensional wind tunnel consisting of a parallel section followed by a divergent section with a total included angle set at either 2 deg., 4 deg. or 6 deg. The installation and instrumentation are described, in particular a constant temperature hot-wire anemometer. Measurements were taken in the horizontal mid-plane of the tunnel along lines at right angles to the axis, of the mean speed and the speed fluctuations, and various velocity parameters were obtained. These findings revealed the existence, at a certain distance from the beginning of the divergent portion, of a regime of equilibrium for which the distributions of the mean speed are related, as well as those of the squares of the velocity fluctuations. The alternation of laminar and turbulent regimes near the wall was also demonstrated.

Les centrales nucléaires. By P. CHAMBADAL. Collection Armand Colin No. 321. Librairie Armand Colin, 103, Boulevard Saint-Michel, Paris (5e). Price Ffr.300.

NUCLEAR power stations can be built on the basis of many different systems. The classification adopted here is according to the working fluid, which can be either steam or a gas. The first of these two main categories can be sub-classified according to the modes of production of the steam (by means of boilers, heat exchangers, or the reactor itself). Each of these possibilities is illustrated by one or more examples. In this way the author covers all the main nuclear power installations which have so far been built or are under construction in France, Great Britain and the U.S.A. Economic considerations relevant to the production of nuclear power are not touched upon.

Obituary

H. S. BROOM

WE record with regret the death of Mr. Harry Skeet Broom, which occurred at High Wycombe on September 12. Mr. Broom, who was in his eighty-fourth year, was the founder, chairman and joint managing director of Broom and Wade, Ltd. ; he continued to take an active part in the affairs of his company until a few weeks ago. Mr. Broom came of a Norfolk farming family. As a young man he turned to an engineering career and founded his business in 1898. At that time he devoted himself principally to the manufacture of woodworking machinery for the furniture industry. But as the firm progressed, there were developments in other directions and, for many years past, the work of Broom and Wade, Ltd., has been concentrated upon the production of air compressors and pneumatic equipment. Under Mr. Broom's inspiring leadership, a family business with quite small beginnings has been extended to many countries overseas. Furthermore, during the lifetime of its founder it has had to meet the demands of two world wars. In the first world war, howitzer shells were turned out in large quantities under the direction of H. S. Broom, while in the second world war the firm was called upon for a great deal of work concerned with the production of Churchill tanks.

H. S. Broom

Mr. Broom was a member of the Institution of Mechanical Engineers and a past-president of the British Compressed Air Society. He was a keen sportsman, particularly as a yachtsman and in the hunting field.

Baroque Tendencies in the Evolution of the Gravity Dam

By SERGE LELIAVSKY, Ph.D., M.I.C.E., M.Am.Soc.C.E.

No. II—(*Concluded from page 455, September 19*)

The author began by outlining an analogy between the style, which in the history of art is described as "baroque," on the one hand, and the "buttress" or "hollow" type of dams, on the other. The pros and contras of this last type were then considered, both as regards technical advantages, and war risks. Three stages in the historic evolution of the type were illustrated by means of examples, starting with the Theresa dam (1903) and ending with a number of works which have just been completed, or are still under construction. The stress analysis characteristic of the type is outlined and the advantages of various modern improvements assessed.

Stress Calculations for Buttress Dams

ONE of such methods is outlined by Professor A. W. Hendry in a paper on "Photoelastic Experiments on the Stress Distribution in a Diamond-Head Buttress Dam," published by the Institution of Civil Engineers, London, *Proc.*, Part I, May, 1954, page 370. The Navier principle of linear normal-stress distribution for horizontal planes is postulated *ab initio*. The problem, then, is confined to finding the corresponding shearing stresses and the normal stresses on vertical planes. We consider a horizontal slice of the material of the dam of very small (but finite) thickness, δh. In section, in Fig. 6, this slice is marked by the letters *efij*.

Over a length x from the face, the forces acting on this slice are then as follows :

(1) The "inner" downward vertical force acting on *ei* :

$$\frac{Pa}{A}+\frac{M}{I}m$$

in which :

P is the vertical component of the resultant.
A is the total area, corresponding to x.
a is the part of that area, corresponding to x.
M is the bending moment.
I is the second moment of the section about the neutral axis.
m is the first moment of a about the same axis.

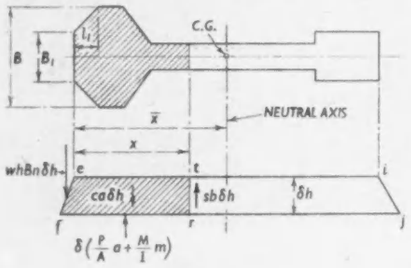


Fig. 6

The difference between this force and a similar "inner" force applied upwards to the bottom of the slice is :

$$-\frac{\delta}{\delta h}\left(\frac{Pa}{A}+\frac{Mm}{I}\right)\delta h.$$

It will be this difference, which will appear in the final equation for the net resultant of all the forces acting on the slice.

(2) The shearing force applied to the area *tr*, namely, $sb\delta h$, in which s is the unit shearing stress and b the width of this area.

(3) The weight, $ca\delta h$, where the symbol c represents the specific structural weight of the material.

(4) The vertical component of the hydrostatic pressure for the surface *ef*. If w represents the weight of a unit volume of water and n the upstream batter, then this component is given by $whBn\delta h$, B being the breadth of the section on which water pressure acts (see Fig. 6).

The equation of static equilibrium can then be written as follows :

$$sb\delta h=ca\delta h+whBn\delta h-\frac{\delta}{\delta h}\left(\frac{Pa}{A}+\frac{Mm}{I}\right)\delta h.$$

From this formula we find that the unit shearing stress s, as $\delta\to 0$, is :

$$s=\frac{ca}{b}+\frac{whBn}{b}-\frac{1}{b}\frac{d}{dh}\left(\frac{Pa}{A}\right)-\frac{1}{b}\frac{d}{dh}\left(\frac{Mm}{I}\right)=\frac{ca}{b}+\frac{whBn}{b}$$
$$-\frac{P}{ab}\frac{da}{dh}-\frac{a}{b}\frac{d}{dh}\left(\frac{P}{A}\right)-\frac{M}{Ib}\cdot\frac{dm}{dh}-\frac{m}{b}\frac{d}{dh}\left(\frac{M}{I}\right).$$

All the terms appearing in this equation are capable of being evaluated from the known dimensions of the dam and the numerical value of the shearing stress can thus be found.

In the same order of ideas, Professor Hendry finds for the horizontal component, $Hb\delta h$, of the inner force acting on the surface *tr* the formula :

$$Hb\delta h=whB\delta h-\delta\int_0^x s\,.\,bdx,$$

and thus, obtains for the normal stress, H, on vertical planes, the equation

$$H=\frac{1}{b}\left(whB-\frac{d}{dh}\int_0^x sbdx\right).$$

The main problem here is to determine numerically the value of the integral (in the second term, in the brackets) on the right-hand side of the formula. Professor Hendry shows that this integral can be developed into a polynomial, composed of five terms, as follows :

$$\int_0^x sbdx=K_3\frac{a}{b}+K_3(x-l_1)+K_1a+K_2(a\bar{x}+m)$$
$$+K_4(ax-a\bar{x}-m)+K_5[m(x-\bar{x})-I']$$

in which K_1 to K_5 are coefficients, capable of being calculated from the dimensions of the design, I' is the second moment of the area corresponding to x (about the neutral axis) and $\bar{x}$ and l_1 are as in Fig. 6. The separate terms of this equation can be differentiated with respect to h, and will then yield the value of

$$\frac{d}{dh}\int_0^x sbdx$$

which is required for finding H.

It is thus shown that all the three basic types of stresses in the buttress can be figured out and will finally yield the ellipses of stresses and the principal stresses. Professor Hendry says, however, that in a stress analysis according to this method, "the equations were rewritten in terms of a number of cross-sectional constants, to reduce the labour of the calculations which, nevertheless, remained very lengthy."

Personally, in performing calculations for such dams, the author prefers to use a method of his own,[7] which is a finite-differences method, and possesses the practical advantage of allowing each member of the team engaged in the relevant arithmetics—which is always a rather arduous problem in this kind of stress analyses—to be fully aware of the general trend of the computation, in which he takes part, and to visualise easily the grouping of the values he is dealing with. To avoid errors, he can (and must) prepare, as work proceeds, sketch diagrams, permitting the verification of the results as and when they become known, against earlier results, which are then supposed to have already been checked. This, of course, is a matter of office routine, which is nevertheless rather important. It must be realised, however, that whichever method is used, provided Navier's principle is adopted as basis and no slips occur, the results must always be axiomatically the same, the order of precision depending on the number of decimals and on the smallness of the size of the finite difference taken as basis for the numerical calculation.

There are, however, certain general qualifying remarks, applicable to all the shearing stress calculation methods of the same group, i.e. methods which are confined to conditions obtaining in the axial plane only.

It will be remembered in this connection that the bases of the modern shearing-stress analysis were laid down, in the middle of the

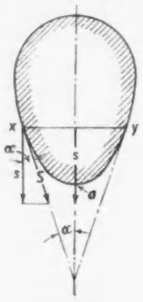


Fig. 7

last century, by Barré de Saint-Venant. Investigating mathematically a number of sections, he came to the conclusion that the maximum shearing stresses in a section depended (in a rather involved way) on the elastic distortion of its plane, but generally tended to increase towards the periphery ; viz., tangential shear intensity was, as a rule, the greatest. Since this result does not affect the shear distribution in a rectangular section, it seems to be frequently forgotten or overlooked, but classical authors, e.g. Professor Mehrtens,[8] Professor Föppl[9] and others, maintain that the maximum unit shear on the periphery of non-rectangular sections is tangent to the outline, as shown in Fig. 7, and is, consequently, equal to $S=ks=s\sec\alpha$, in which s is the axial shear, and k a coefficient presumably equal to $\sec\alpha$. These inclined stresses are obviously higher than the axial stresses we have thus far calculated ; for instance, according to this theory, S should be about twice the value of s, in the case shown in Fig. 8.

It should be realised, however, that an unqualified application of these conclusions may occasionally lead to somewhat surprising results. Consider, as an example, the point a, Fig. 7. Here k is infinite, which seems rather odd, even though s tends to zero. Still more awkward results would be obtained if we should try to find the maximum inclined shearing stresses—according to this theory—for the inner faces of the

[7] Still unpublished at the time these lines were written.
[8] *Statik und Festigkeitslehre*, Vol. I, page 366.
[9] *Resistance des Materiaux* (French translation), page 118.

flanges in a common rolled joist. It should, nevertheless, be placed on record that the quoted classics—i.e. both Mehrtens and Föppl—are, to a certain extent, aware of the limitations of the operating principles of their method.

On the other hand, in view of the uncertainty associated with this theory in general, it was only to be expected that engineering

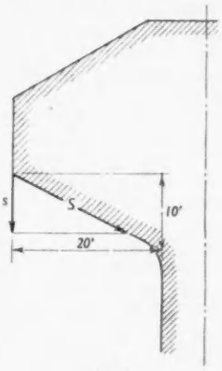


Fig. 8

interest should focus on the investigations tending to solve the problem by other means. In this connection attention will be directed again, to Professor Hendry's paper, which has been already quoted.[10] It describes a most instructive attempt to verify the calculated stresses in a buttress dam (Errochty dam in Scotland) by means of the well-known "frozen stress" method of photo-elasticity. The investigation comprises three-dimensional tests, for the buttress in general, and a set of two-dimensional experiments, for its diamond head in particular. The three-dimensional tests were carried out separately for (*a*) the gravity effect and (*b*) the hydrostatic pressure. The gravity forces were simulated by rotating the buttress model in a centrifuge, at a speed of 160 revolutions per minute (40g). At the same time the temperature of the model was raised to 87 deg. Cent., kept constant for 1½ hours and then cooled down to normal during a period of 2 hours; during all of which the machine was still kept running at the same speed. The fringe pattern thus obtained displayed a fair margin of agreement with calculated stresses, but showed, also, that the result depended to some extent on the rigidity of the foundation material. In fact, higher shear intensities were obtained for the case when the foundations were less flexible.

In the test (*b*), i.e. those for water pressure, a battery of hydraulic rams was used in place of the centrifuge, the effect thus obtained being adjusted in such a way as to keep the true proportion between the two types of loadings, as it existed in Nature.

In order to obtain information on the stresses existing within the material of the head, the model of the latter with the stresses "frozen" in it was cut into slices normal to the upstream surface and to the vertical plane of symmetry. Examination of these slices in polarised light yielded "fringe" (isochromatic-line) diagrams, but failed to supply an exhaustive reply for the stress problem, since it gave the $P-Q$ values only (differences between principal stresses in a point) but not the sums $P+Q$, which would have been necessary for finding P and Q separately. Under other conditions the $P+Q$ curves can be found by precise measurements of the thickness of the slice, before and after the test; which, however, was obviously impracticable in the present case.

The solution adopted was then as follows:

[10] Page 490.

an identical slice of unstressed material was subjected to a similar peripheral loading, and the fringe diagram thus obtained was compared with the original diagram.

Up to a point these two diagrams were found to bear a certain degree of likeness to each other, but whether this fact (if taken alone) suffices to justify the conclusion to the effect that all the stresses were identical in the two-dimensional and three-dimensional tests respectively, may be a matter of opinion. Particularly so, since the ultimate result derived from this assumption is diametrically opposed to that of Mehrtens and Föppl; i.e. according to Professor Hendry the shear intensity is greater in the regions close to the axis rather than at the perimeter of the section, whereas Mehrtens and Föppl believe that the maximum occurs at the edges, whilst the minimum is located near the centre line. Should the scope of Professor Hendry's interesting and valuable experiments be amplified by new tests, this particular point must call for special attention.

Another aspect of the design problem for buttress dams, is that of ensuring that there will be no tension on vertical planes in the head, which might have been otherwise provoked by the local effect of the water pressure. The better to follow the conditions of this problem, attention is called to Fig. 9, showing the section of a diamond head.

Considering the hydraulic force, H, alone, it is required to find the maximum safe value of a, corresponding to given values of b and c (see Fig. 9). In investigating this problem it will be found that to ensure that there are no tensile stresses at point A, the point E, in which the force H strikes the base AB, must fall within the middle-third of this base. Hence

$$f \leq \frac{2}{3}b.$$

Since the triangles ABC and AEG are similar

$$\frac{e}{c} = \frac{f}{e/2}$$

and

$$f = \frac{e^2}{2c} = \frac{a^2+c^2}{2c} < \frac{2}{3}b.$$

We thus obtain for the safe value of a the formula

$$a = \sqrt{\frac{4}{3}bc - c^2}.$$

This approximate, simple equation is in satisfactory agreement with practice, and,

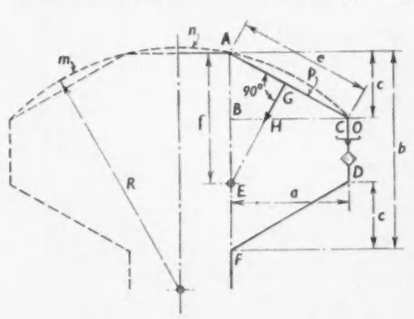


Fig. 9

although it does not take into account various additional factors—such as the hydraulic effect on CO (i.e. the part of the joint subject to full water pressure), the interstitial water pressure on the base AF, the component of the structural weight depending on the slope of the upstream face, &c.—it may, nevertheless, serve for a preliminary lay-out, to be subsequently adjusted (if deemed necessary) by more exhaustive analysis.

For instance, take $b=30$ft and $c=10$ft. The formula will then yield

$$a = \sqrt{\frac{4}{3}30 \times 10 - 10^2} = \sqrt{300} = 17{\cdot}32\text{ft},$$

which is in a fairly close agreement with one of the recent Scottish dams, in which, for

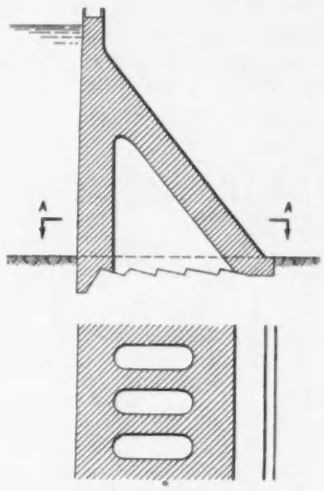


Fig. 10—Figari's proposal

the same values of b and c, the value of a was 17·5ft.

Should, however, a more comprehensive solution be aimed at, a graphical computation may be employed as follows. We assume a certain average water pressure P, and then draw graphically the resultant of the following forces:

(*a*) Main hydraulic force $H=P\times c$.

(*b*) Water pressure in the joint, $P\times OC$, acting at mid-distance between C and O.

(*c*) Interstitial hydraulic pressure $\frac{1}{2}\times 0{\cdot}91 \times a \times P$; this force is applied at one-third distance between A and F; note that 0·91 represents here the effective area.[11]

(*d*) Component of weight $\frac{a(b-2c)}{2}\times\gamma\times$ sin α, in which γ is the structural unit weight of the material, while α is the angle between the front face of the dam and the vertical.

It will be observed that the first three forces are all proportional to P, and it follows, therefore, that the position of the resultant of these forces does not depend on the depth of the section below the water surface. On the other hand, the weight remains constant for any depth, so that the combined resultant of the hydraulic and gravitational forces is a function of the level. But then, the influence of the gravitational force is a significant factor for the upper levels only—where the hydraulic stresses are generally very low—whilst at greater depths the hydraulic forces are predominant, which explains why the gravitational force is frequently neglected in such calculations altogether.

Note that for a mushroom head—as indicated in the drawing by the dotted line *mnp*, the radius of which is R—the computation will be precisely the same, and the formula is, therefore, equally valid in both cases.

Should a dam of this description be provided with an overflow, the concensus of general opinion tends to prefer arrangements in which the "nappe" strikes the channel bed beyond the toes of the buttresses. To this end, overflow buttress dams are frequently

[11] Serge Leliavsky Bey, "Experiments on Effective Uplift Area in Gravity Dams," *Trans. Amer. Soc. Civ. Eng.*, Vol. 112, 1947, pages 480 and 481.

provided with downstream decks diverting the flow of the falling water. In buttress dams of the second group these downstream decks are often built of precast beams, allowing easy and cheap erection, and a certain degree of freedom of movement of individual buttresses in the completed work. They are therefore disregarded in the calculations (except, perhaps, as an additional load).

Latest Advance (Class (*c*))

The principle of the hollow dams which constitute the main item of the third group,

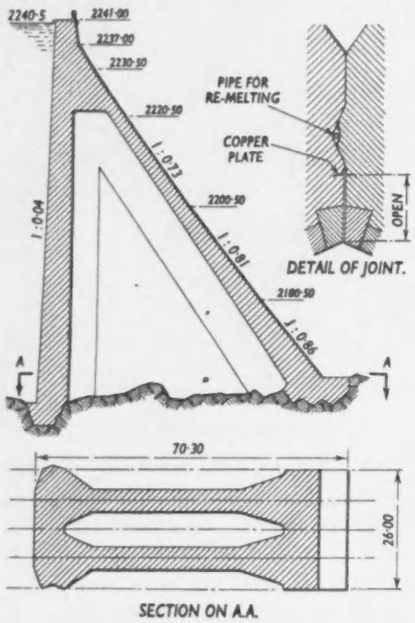


Fig. 11—Profile and part plan of the first Dixence dam

is not new. For since earlier days of the dam-building era, it must have lingered in the subconscious background of the minds of engineers, at least in so far as advanced design was concerned. Proof thereof is supplied in Fig. 10, which, Dr. Kelen tells us,[12] represents the system due to Mr. Figari. From the modern designer's standpoint the chief objection to this arrangement is that it is bound to result in a spider's web of fissures and cracks, radiating from each cavity provided in the thickness of the dam. The remedy is obvious—expansion joints, starting from the cavities in the dam and ending at its two faces. The rather peculiar point characteristic of the modern application of this general principle is that the buttresses are in this case grouped in pairs, i.e. that the expansion joints are arranged at every second cavity, and not at each and every cavity, as one might have, perhaps, expected. The idea of grouping the buttresses in this manner seems to have first been applied (1931–35) in the earlier Dixence dam in Switzerland (consulting engineer Professor A. Stucky, Lausanne), as seen from the sections reproduced in Fig. 12.[13]

The object of the arrangement appears to have been twofold : (*a*) to prevent (or reduce, at least, partly) the accumulation of large masses of ice and snow between the individual buttresses, whilst lessening, at the same time, the total superficial area of the masonry work (concrete with rubble facing) exposed to the direct action of the frost—these requirements being of primary importance in this particular instance, owing to the rigours of the climate, consequent on the high altitude of the site (about 2240m above sea level)—and (*b*) to allay all fears as to possible lack of rigidity that might have existed, had individual buttresses been left standing unsupported on either side. It seems that such fears were actually vented, at the time when this dam was planned and built, particularly in regard to eventual buckling of the relatively thin webs. Later tests showed, however, that such fears were groundless—an experimental conclusion fully confirmed by the rather wide practical experience accumulated in later years.

Still, there cannot be any doubt whatever that a structure consisting of paired buttresses possesses a very much greater transverse stability than the usual type of buttress dams, herein classified under group (*b*), and this fact deserves to be borne in mind when comparing the respective advantages of the various types.

Owing to the particular geological formation at the spot on which the dam was built, it was curved in plan, but no advantage was taken, in designing it, of the arching effect, because of the open joints between the individual blocks. It is, nevertheless, believed that the curvature of the axis of the dam in plan is an advantage, for it is instrumental in introducing a set of useful " secondary " stresses.

On the other hand, the curvature of the axis has forced the designer to adopt a variable thickness of the web, increasing from the bottom to the top of the buttress ; in fact, since, owing to the curved layout, the webs of the different buttresses are not parallel, the re-entrant angle at the downstream end of the cavity would have been a variable depending on the height, had the thickness of the web been constant; and this would have then resulted in an awkward conical shape of shuttering, for casting the adjoining concrete. To avoid this the variation of the web thickness was adjusted in such a manner as to obtain a cylindrical coffering, of constant angle and radius, for the entire height of the cavity.

Another point deserving mention is the polygonal outline of the outer facing of the dam. The slanting parts on either side of the straight, middle portion of this facing (see same Fig. 11) have been provided in order to achieve precisely the same effect, which was investigated earlier, in Fig. 9 ; i.e., to prevent local tension occurring on vertical planes. It must be realised, however, that whether the corners are bevelled or not, the resultant of the hydrostatic forces coming here into consideration remains the same. Though on the other hand it may also be argued that a water pressure applied to a free, entirely open, external surface might be more obvious than in the case of a face of an expansion joint, which can be obstructed by debris, &c., and become blocked, thus ceasing to function as a free water channel. Viewed from that standpoint the bevelling of the corners may be fully justified.

From the standpoint of the designer who loves his job, it is a pity that the cavities which formed originally the outstanding feature of this remarkable work, were later filled in with concrete (for strategic reasons), after the dam had rendered excellent service for many years, and also that it is destined in the future to remain forever submerged

[12] *Loc. cit.*, page 3. The system was used partially in the Pavana dam, in Italy, in combination with the multi-arch principle (*Ibid.*, page 246).

[13] Commission Suisse des Grands Barrages, " Mesures Observations et Essais sur les Grands Barrages Suisses, 1919–1945," Berne, Suisse, 1946, article by Professor Stucky.

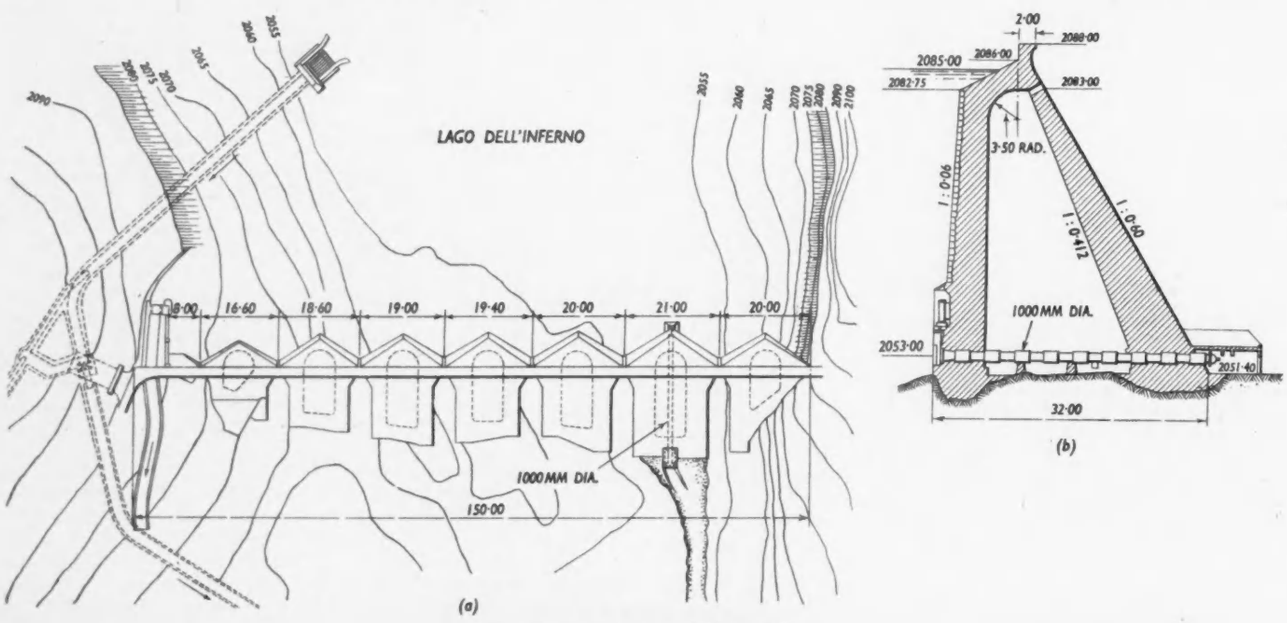


Fig. 12—Plan and section of Inferno dam

by the waters impounded behind a higher dam which is in course of being built below it.

It remains now to consider Dr. C. Marcello's valuable contribution to the steadily improving technique of this interesting type of dam. We shall use for this purpose

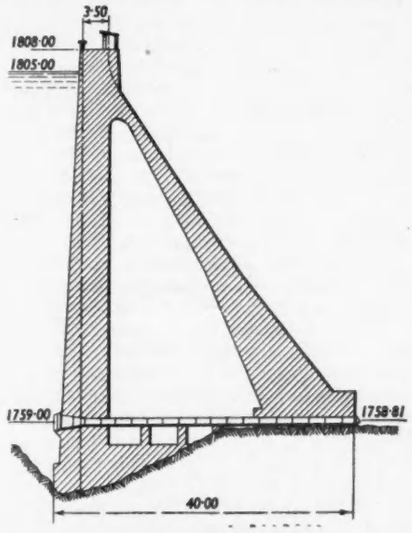


Fig. 13—Trona dam

the three dams described in his publication quoted earlier,[14] namely the Trona dam (see Fig. 13), the Inferno dam (see Fig. 12) and the Bau Muggeris dam (see Fig. 14). The first two dams are located in Italy, whereas the third one, is situated in Sardegna.

The Trona dam is generally similar to the earlier described dam of Dixence, except that it is straight instead of being built on a curve, but the Inferno dam has two distinctive characteristics deserving to be mentioned in

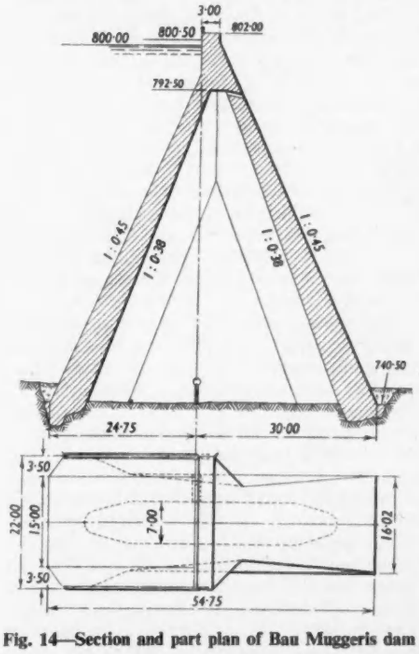


Fig. 14—Section and part plan of Bau Muggeris dam

even a brief résumé, namely, it is provided, at the top of its upstream face, with a special device intended to reduce the effect of the ice pressure (altitude 2100m above sea level) and that every monolithic block is specially designed, depending on its height, in such a manner as to achieve maximum economy.

On the other hand the Bau Muggeris is an entirely novel design. According to Dr. Marcello he first suggested this type as early as 1941. It is the most economical of all the buttress dams, both in regard to volume of material and total cost.[15] As seen from Fig. 14 the shape of the blocks is carefully studied to achieve maximum efficacy and ensure adequate resistance.

The main difference between this latest type and the group of designs of the Dixence class is that instead of the almost vertical upstream faces of the earlier layout, we have now a profile in which both faces are built at a slope of 0·45. In this manner, advantage is taken of the vertical component of the water pressure—a point the importance of which has already been stressed.

Although the technique of this sort of device is steadily improving and we must, consequently, foresee further advances in that branch of engineering in the future, it is, nevertheless, a fact, that the Bau Muggeris type represents a milestone in the history of this evolution, for it was immediately followed by the construction of a large number of other dams, designed by Dr. Marcello according to the same principle, e.g. the Poglia dam, the Sabbione dam, the Pantano d'Avio dam, the Ancipa dam, &c.

[15] See page 453 *ante*. Note that Figs. 13 to 15 are abstracted from this article.

The Science Museum Revisited

By HUGH CLAUSEN

FIFTY years or so ago, when I was a student at the "Central," I often went to lunch in the Science Museum, a very different place from what it is now. There was a little refreshment stall with a few tables and chairs packed away in a corner among the exhibits, with Stephenson's old "Rocket" engine and "Puffing Billy" so close that we had to squeeze by them to get to our chairs. I remember that my standard lunch cost me 4d.—a cup of "coffee," roll, butter, and cheese, one penny each.

Apart from occasional visits to look up some special exhibit I saw very little of it until well after the last war. An interest in the history of engineering led most of my attention to the older exhibits, and doubts grew as to whether the name Science Museum was a good one. The older exhibits certainly were more the creations of technology than of science, and this tendency seems to have continued. The exhibits seem to divide themselves naturally into two classes—those where science dominates over technology, and vice versa. In my imagination I removed all the exhibits in which the major interest was technology, and I found there was very little left.

There were Foucault's pendulum, geometrical models, a number of more recent exhibits of crystalline and atomic structure, optical systems, Faraday's experimental apparatus, models of early physical apparatus like Atwood's machine, or that used by Boyle, calorimeters, Magdeburg hemispheres, Leyden jars and the like, and a range of scientific instruments, as well as some of the exhibits in the children's gallery, but hardly enough to fill one of the larger galleries. Quite clearly the museum to-day is a museum of technology, with a strong bias towards engineering; and as far as can be seen it always was like that. Why was it misnamed?

This question cuts deep into our national consciousness, especially when it is realised that the word "technology," so glibly used to-day, was hardly ever used at all before the last war, and, together with another word, "logistics," was classed as an American innovation, instead of them being as they were and are, good English words. The reason for these words having practically gone out of use may be that the underlying ideas behind them (see any dictionary for definitions) seem to have become somewhat atrophied since, let us say, the Great Exhibition of 1851.

Next door to the Science there is the Geological, and next door to that is the Natural History Museum. Both these deal with scientific matters, but the exhibits in both are mainly—or were originally—the works of nature rather than, as in the Science Museum, the works of man. Is this a good classification? I think not, as just over the way there is another one, the V. and A., devoted entirely to the works of man, with exhibits of metal work and clocks which might just as well be in the Science Museum as in the V. and A. These mostly date from the days before the separation between the technical and the æsthetic outlook; before craftsmanship and "The Arts" had wandered off on their separate paths, to their common serious loss. Seeking the meaning of the word "science" among all these museums devoted to it leaves one rather confused.

The special significances that words acquire are strong evidences of trends of thought. Although when I was a young man the word "science" was on everyone's lips, the word "scientist" was used very rarely. Few, if any men, however eminent, would presume to apply the word to themselves: it is too all-embracing. I well remember the shock I felt at a debating society meeting when one of the contestants came out with: "If I, as a scientist, can believe so and so . . . &c." It sounded presumptuous; he was an M.A. of Dublin University, but he was an engineer rather than a scientist. In my one volume encyclopædia, published at about the same time—1907—the word "scientist" is used only of one man. The great Darwin was a naturalist, Lord Kelvin was a physicist, Faraday was a natural philosopher, and so on. It seems to me to be a better way. The word "technologist" was unknown until a year or so ago, and even then it should never have been used at all. Its use to-day is to be very strongly deprecated.

For some reason the idea grew up, especially in educational and academic circles, that though "science" inevitably (though regrettably) had to be admitted in learned circles, anything that smacked of trade or industry was taboo. The word "engineer," in spite of the well-recognised professional societies and the great works of Telford, James Watt, Smeaton, Brunel, &c., became associated with the mechanic, the workman wearing greasy overalls, with a spanner in his hand. The early prejudice against naval engineer officers was perhaps the blackest example of this particular snobbery, though this was not an isolated case.

This curious attitude still survives. The whole country was—and some of it still is—

[16] See page 453 *ante*.

split by the cleavage of thought involved in the expression " the modern side " ; science and technology considered as one group, as opposed to the humanities and the arts. Perhaps an even more serious cleavage is the later one, between " science," on the one hand, and " technology " or even applied science, on the other. Even now the superiority of pure science (whatever that may mean) over applied science, technology, or engineering—which is very much more than applied science—is firmly though quite erroneously fixed in the minds of many otherwise quite knowledgeable people.

In the foundation days of the Royal Society the brilliant group of men who founded it under the patronage of Charles II were all keenly interested in the practical applications of the new knowledge they were acquiring and collecting. It was not until after the time of Newton, whose intellectual power did not prevent him from being quite a skilful mechanic, that the Society as a whole floated off into the stratosphere and, to all practical purposes, eliminated the technology aspect of its work. This would not have mattered if it had not, in later years, become scientific adviser to the Government, with wide powers in the administration of research funds ; nor if the idea had not got firmly fixed in higher administrative circles that scientific activities include engineering.

The effect of this unrealistic attitude at the higher levels seems, as far as I have been able to discover, to have created a distorted outlook throughout the whole country. What a pity it is that the old phrase " Natural Philosophy " has nearly died out. The idea behind it, properly developed, could have been the starting point of a synthesis between the classic and the technical outlook which would have enriched them both, instead of the present destructive dichotomy, which has impoverished them. By insisting on an essential difference between education and technical education our old claim of being the workshop of the world has been nullified.

Other countries, now our very serious industrial rivals, seem to have fared better. It seems that in Germany the older universities refused at first to have anything to do with technical education. The necessity for this was, however, so clear to the various state authorities that the foundations were laid of the Technische Hochschule system. These institutions soon established a university level of thought ; whereas with us the polytechnics or technical colleges carried little or no esteem, and only reached an adequate level in very rare cases. Something of the same sort happened in Switzerland and Holland, and in the U.S.A. The institutes of technology soon reached a university level. We were left as about the only country where technology had lost esteem, and with it we lost our old leadership in many essential activities—clocks and watches, precision machine tools, textile machinery, scientific instruments, and other things—just at the time when higher developments were most needed.

The young man of to-day is attracted by the glamour of what is presented to him as science, but he seems to shirk the more severe discipline of technology involved in engineering work. A generation of university graduate engineers is now growing up whose grasp of creative engineering work seems to be sketchy. There is the further danger that the changes taking place in the establishments now being developed into colleges of higher technology will tend to follow the lead of most university schools of engineering, in devoting so much time to theory as to lose touch with reality, and produce a race of men unable to teach, guide or inspire their draughtsmen or craftsmen.

There is very much more in engineering than merely applied science. Much in electronic work can be so described, as the transfer from circuit diagram to hardware is a simpler one, with many components available on the shelf ; but I was looking the other day at a locomotive boiler being fitted with new tubes, and a new firebox, specially made for it. There was also a complex locomotive cylinder block being marked off for machining. The experience was salutary, the latter example in particular showing all the mature experience necessary for the design in the first place, the drawings, the pattern making and foundry work, machining and assembly. It took me back in thought to visits to marine engine building shops fifty years ago, and added weight to Sir David Pye's reference to " The yawning gap between the product of an engineering course and the qualified engineer." This gap is equally apparent in our modern rolling mills, atomic power stations, and diesel-electric locomotives.

In spite of all these musings the Science Museum is not likely to change its name, any more than the educated British public is ever likely to realise how the normal apparatus of civilisation comes into existence. It would, however, be a good thing if journalists and others who write about these matters would at least try to understand something of the creative process, and realise how much, how very, very much we now depend on foreign talents and skills because technology has been neglected at our higher intellectual and administrative levels.

The word " museum " is often associated in people's minds with a collection of things of the past. One of the finest early examples of what is now called automation is in the Science Museum : some of the block-making machinery from Portsmouth Dockyard, designed by Mark Brunel, and built by Henry Maudslay nearly 150 years ago. Looking at this, and other early machine tools in the same gallery, one cannot help wondering whether the popular idea of a museum is not right after all, the (misnamed) Science Museum being, in spite of the magnificent work of the staff, not so much a source of inspiration to our present and future engineers as the burial ground of our industrial leadership.

Interchangeability in the Inch and Metric Systems*

IN recent years there has been a significant move to ensure that it becomes the practice of the International Organisation for Standardisation (I.S.O.) to issue I.S.O. recommendations in inch and in metric values jointly. The requirements of the inch-using countries were brought into prominence at the I.S.O. plenary meeting which was held at Stockholm in 1955 and arose primarily from work which had been done by ISO/TC5 on pipes and tubes.

Recently the B.S.I. Export Panel has placed considerable emphasis on the necessity to promote increased efforts to secure agreement on dimensional standards which will provide functional interchangeability between products and components, whether measured in inch or metric units, and where this is impracticable to see that the dimensions in inch units are always included on an equal basis with the metric. This has become of prime importance because of the signature of the Treaty of Rome and the formation of the European Economic Community, together with the proposals for a wider free trade area in Europe.

Functional Interchangeability

The I.S.O. Standing Committee on Scientific Principles of Standardisation (STACO) have considered a definition for functional interchangeability and recorded that this is achieved when those characteristics of the finished product which affect its operation have been standardised to the necessary degree of accuracy. This frequently includes characteristics other than linear dimensions. In most cases the complete standardisation of all characteristics is neither possible nor necessary. Technical committees should therefore study very carefully which characteristics ought to be standardised, and to what accuracy, in order to ensure the required degree of functional interchangeability. Dimensional interchangeability is a partial aspect of functional interchangeability and is achieved when the linear dimensions of two finished products are sufficiently close to one another to ensure interchangeable replacement.

Corresponding Values

It is difficult to obtain international agreement on dimensional standards which will satisfy the requirements of countries using inches, pounds, &c., and those using millimetres, kilogrammes, &c. There is a tendency for each country to retain its own system and a natural liking for round numbers, but there is a possibility that many of the present discrepancies could be resolved by much closer attention to the real significance of figures rather than their expression in one system of measurement or another. This concept was the basis of the workable solution which was put forward by the British delegation of ISO/TC5/SC1 at Stockholm in 1955, and which is referred to as the use of "corresponding " values.

This system consists in expressing a dimension both in inches and in metric units to a sufficient degree of accuracy to ensure practicable interchangeability. Thus, if only approximate accuracy is required, reasonably round numbers can be used in both systems. For example, for the length of a tube, 7m can be taken to " correspond " to 23ft ; similarly, 0·176in (7.s.w.g.) is sufficiently close to 4·5mm to provide interchangeability where pipe thickness is concerned. On the other hand, the dimensions of a screw thread gauge may well have to be given to several places of decimals to ensure exact interchangeability. It is therefore necessary to consider how accurate the equivalents of the metric and inch units have to be to ensure adequate interchangeability.

Implementation

It is felt that the implementation of the above concepts is retarded by lack of adequate publicity and recommendations have been made to B.S.I. by the Technical Committee MEE/129 for wider publicity throughout the B.S.I. technical committees and the U.K. delegations.

* Communication from the Engineering Equipment Users Association, 20 Grosvenor Gardens, London, S.W.1.

Naval Electrical Branch

By OUR NAVAL CORRESPONDENT

UNTIL the end of the second world war the maintenance of electrical, including radio, equipment in a warship was carried out by officers who were specialists in three different branches. The Torpedo Officer was responsible for the generation and distribution of basic electrical supplies and for the maintenance of all the electrical equipment associated with this requirement. He was also responsible for the maintenance of the gyro compass and for the electrical portions of weapon control and their mountings in addition to certain "domestic" equipment. The Communications Officer looked after W/T equipment and the Radar Officer all the radar equipment. During the war the radar officers and their staffs were in fact R.N.V.R. officers and hostilities-only ratings and thus, with demobilisation, the maintenance of radar equipment when the war came to an end became a serious problem. The Board of Admiralty had for many years been aware of the possible need to integrate electrical responsibilities and as a result of the impact of the last-war developments in the large-scale application of electrical and particularly electronic devices, the then Rear Admiral Sir Henry Phillips was requested to prepare a report on the subject. Based on his conclusions, a committee under the then Rear Admiral G. B. Middleton drew up a detailed report in 1945 recommending the introduction of a force of highly trained officers and men capable of maintaining all electrical equipment in a ship or aircraft at the highest possible pitch of performance. On the question of the headquarters organisation the committee suggested, as an interim measure, the setting up of a Naval Electrical Department, pending the establishment of an Electrical Engineer-in-Chief's Department responsible for all naval electrical material. Concurrently arrangements were to be set in train to "navalise" the existing civilian Electrical Engineering Department over a period of 15 to 20 years, the old and the new departments merging at some suitable stage. Apart from the recommendation that the Head of the new branch should assume responsibility also for research and design of radio material, the Board approved the report and in 1946 the Electrical Branch of the Navy was born under a Director—the D.N.L.D.—who is charged with advising the Board on all matters concerning that branch.

Material

The D.N.L.D.'s responsibilities in the material field are accordingly governed by these interim arrangements. Reflecting the duties and responsibilities of ships' electrical branch personnel for all electrical equipment —including W/T, Radar, Asdic and indeed all electronic material—the D.N.L.D. similarly bears the headquarters responsibility for maintenance over this extensive field. Thus he is given wide powers to represent the maintenance aspects of design, and electrical specialists are appointed to all R. and D. establishments to ensure that his maintenance policy is applied from the earliest stages of design. Both scientific and naval staffs welcome this close association, which has paid handsome dividends in the shape of an end product that is more reliable and easier to maintain despite its relatively increased complexity. The interest of the designer is inevitably focused more on defects arising in the early life of a new equipment, but the problem of maintaining ageing material is also important. It has thus become the practice for all reports of defective electrical material or design to be channelled through H.M.S. "Collingwood"—the naval electrical training establishment—and the D.N.L.D. A measure of intelligent filtering *vis-à-vis* age can then be carried out to avoid placing an undue paperwork burden on the designers' shoulders. The D.N.L.D. is also very much concerned with the formulation of Agreed Staff Requirements for new ships and is jointly responsible with the Director of Electrical Engineering for ensuring that the main generator capacity and the converted supplies are entirely adequate when allowance has been made for damage reserve and a percentage margin for growth. In regard to air electrical material—in which sphere the Ministry of Supply and not the Admiralty is the supply department—there is not perhaps the same intimate contact over matters of design compatibility. Moreover, in most instances, projects are of joint concern to the Navy and the R.A.F. with the latter in the role of chief customer. The peculiar problems of the operation and maintenance of aircraft and air equipment from the confined spaces in a warship are liable to be forgotten unless the D.N.L.D. strongly argues the Navy's viewpoint from the very early design stage. It is interesting to note that in the field of electronic engineering applications at sea, the United States Navy Department has recently extended the scope of the Bureau of Ships Electronic Division Director to include authority for the co-ordination of shipboard electronic maintenance policy on somewhat similar lines to that held by D.N.L.D. but with much greater powers.

Personnel

Except at a high cost and for a limited purpose under relatively controlled conditions, it is not practicable to write into a design specification for naval electronic equipment an absolute guarantee of continuous peak performance for a predetermined time interval under conditions of service at sea in peace and war. The accumulation in a ship of electrical devices to serve a wide variety of purposes thus calls for diagnostic and manual skills which are most economically provided by a specialist department led by officers of the highest calibre and professional training. Incidentally, the standing of these officers, both within the Navy and in industry, coupled with their intimate knowledge of their men and the conditions under which the equipment has to work at sea, must in the long run have a beneficial effect on the design and manufacture of that equipment. In personnel matters the D.N.L.D. advises the Board on the entry and conditions of service of officers and ratings of the electrical branch and their training and on the electrical complement of ships and establishments. This co-ordination of entry, training and complementing enables the D.N.L.D. to plan for the introduction of a new weapon or new class of ship to be matched at the right time by an adequate number of trained personnel. Material departments are responsible for advising him of the intention to introduce new equipment when it has reached a practical stage in its development, and are also directed to make prior provision for the installation of an early production model for instructional purposes. It takes 6 to 8 years to produce an experienced officer or petty officer, which is about the time taken to produce a new major equipment. It is important also to note that, being graduate engineers of high quality, officers of the electrical branch have no need to sub-specialise, which ensures flexibility and economy in the officer structure. Though some officers are trained to London University (External) Engineering Degree Standard at the R.N. College, Greenwich, the basic training is 3 years at Cambridge University, followed by a year at sea, then a year spent in industry and finally a year at H.M.S. "Collingwood." This training has been evolved after consultation with the best professional and educational advice, and moulded by experience over the past 12 years. The Admiralty, along with the Navy, faces a period of reorganisation to meet the realities of to-day and it is not yet clear exactly what its new shape will be. What is abundantly clear is that in our future small modern Navy there will only be room for the best, both in material and men. Nowhere will this be more true than in the technical fields and all indications prove that the standard of entry and the method of training for electrical officers recommended by Admiral Middleton and adopted by the Board of Admiralty are sound.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1.

RUBBER-INSULATED CABLES AND FLEXIBLE CORDS FOR ELECTRIC POWER AND LIGHTING

No. 7 : 1953. Amendment No. 3 (PD 2935). Price 1s. The two principal purposes of this amendment are to substitute references to B.S. 2899 for the existing requirements for rubber insulation and sheath and to provide for the manufacture of the smaller sizes of braided and compounded cables without a layer of proofed tape over the insulation. The change in rubber content of general-purpose insulation, introduced in B.S. 2899, has made it necessary to revise the values of minimum insulation resistance specified for cables made with this kind of insulation. The new values are generally about 25 per cent of those formerly required. Revised tables of dimensions are given for those types of cable affected by the omission of proofed tape from the smaller sizes; and the opportunity has been taken to specify some of these dimensions to a greater degree of accuracy than formerly, to obviate difficulties in inspection. The amendment makes a number of other changes in the standard, which affect H.S.O.S. cables, tough-rubber-sheathed flexible cords and unkinkable flexible cords.

The following amendments, necessitated by the changes in B.S. 7, were also published on January 1:

Amendment No. 1 to B.S. 708 : 1957, "Trailing Cables for Mining Purposes" (PD. 2936); Amendment No. 2 to B.S. 1116 : 1956, "Flexible Trailing Cables for Quarries and Metalliferous Mines" (PD. 2937); Amendment No. 3 to B.S. 1862 : 1952, "Cables for Vehicles" (PD. 2938); Amendment No. 1 to B.S. 2008 ; 1953, "Vulcanised Rubber-Insulated Wire Armoured Cables for Collieries" (PD. 2939).

LOW DENSITY POLYTHENE SHEET

No. 3012 : 1958. Price 3s. This latest addition to the series of British Standards for polythene specifies the composition, chemical properties and dimensional tolerances of low density polythene sheet with a maximum nominal thickness of 0·020in. The sheet is primarily for use in conjunction with low density polythene tube and rod (B.S. 1973, 2919, respectively). The publication deals with black and natural colour sheet suitable for general purposes, including those of the chemical and food industry; and with pink and brown coloured sheet for use as external surgical splints. (Pink and brown are specified by reference to the British Standards for building and decorative paints.) The standard concludes with a set of marking requirements, with a note on B.S.I.'s "kite-marking" scheme.

Administration Building at Stanlow Refinery

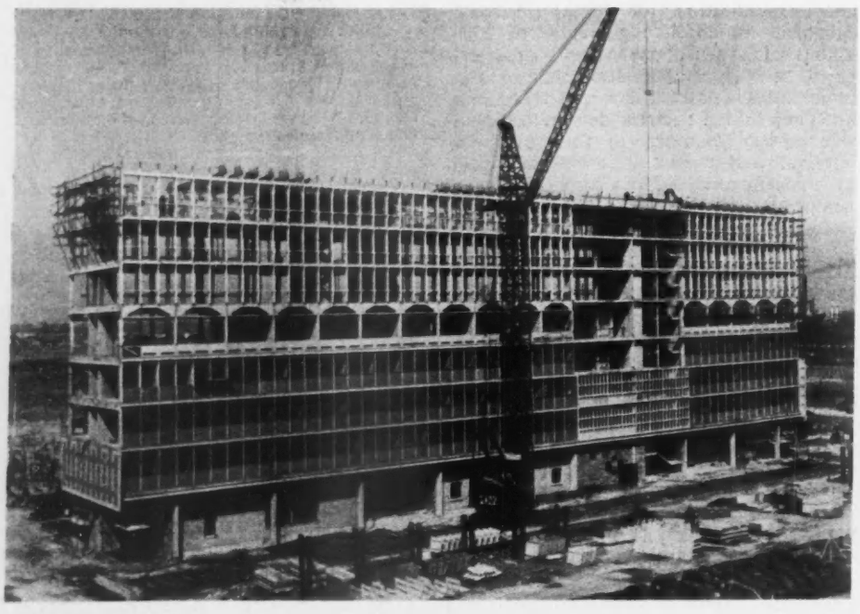
With the completion of the present programme of plant extensions it was decided by the Shell Refining Company, Ltd., that the long deferred plan to provide permanent office accommodation for the staff could be embarked upon. As a result an eight-storey reinforced concrete building about 100ft in height and having a floor area of 100,000 square feet is nearing completion on a central site in the refinery. On the right we reproduce a photograph of a model of the office block and the canteen building showing the north-west elevation.

STANLOW refinery, which began as an installation for the blending and redistribution of products from overseas refineries in 1922, commenced developing into a major refinery with a series of expansion programmes, the first of which was launched in 1937. Since the war development has proceeded and a wide range of plant has been added to make Stanlow a complete crude oil refinery extending over 1800 acres, having a labour force of about 5000 people and refining 500,000 tons of oil per month. During this period of development it has not been possible to allocate capital for the provision of accommodation for the staff, so that temporary hutments have had to serve this purpose for many years. However, with the virtual completion of the major plant extensions and the ever-growing need for a suitable building to house an expanding staff the Shell Refining Company, Ltd., decided to embark upon the construction of an office block.

For this purpose a site in the centre of the refinery was allocated for the erection of the administration offices and, in order to provide for future extensions, while leaving a desirable amount of surrounding open space, a single tall block design was decided upon. Of reinforced concrete throughout, the building, has internal dimensions of 285ft in length by 40ft in width and rises 100ft above the ground in eight storeys over a basement and enclosing a floor area of approximately 100,000 square feet. A staff numbering 400 is accommodated and in the general planning of the building, which is governed by the adoption of a two circulation core arrangement, the accounts and public and industrial relations departments rise together through three floors. The fourth floor is allocated for visitors, exhibitions, &c., and on the floor above are the managerial and related departments with the two remaining floors housing the engineering department, the drawing office being on the top level. Study of space requirements determined a common denominator of floor area and the assumption of 16ft as a desirable office depth resulted in a module of 4ft 9in along the elevations.

Ground conditions called for a piled foundation and each of the Franki piles carries a load of 60 tons. The building itself is in the form of a thin vertical slab stiffened against the wind by the two cross walls of each vertical circulating core to which the floors, acting as deep horizontal girders, transmit the forces. *In situ* concrete has been used for these towers and all work up to first floor level, while above this all main constructional members are of precast concrete. With the exception of the basement slab the floors are of composite construction, 8in deep, consisting of prestressed concrete inverted Tee beams at 2ft 4½in centres, that is at quarter points of each module, with a 2in thick *in situ* concrete topping cast on to a permanent shutter of asbestos cement carried on a continuous rebate in the beam web. A mechanical bond between the precast and *in situ* concrete is formed by castellations on the top of the Tee units. Floor units have spans from external wall edge beams to the spine beam of 23ft 9in and 16ft 5in, thus avoiding down standing transverse beams while the longitudinal beam is formed in the corridor wall. Generally similar construction has been adopted for the roof but a newly developed beam of rectangular design set at 4ft 9in centres and spanning the full width of the building is used.

The modular grid mullions form the load bearing construction of the load bearing external walls, above the first floor, and consist of precast frames, one storey high, formed by two columns and head and sill beams. These are joined by infilling head and sill beams and are bolted together, vertically, within the depth of the floor slab. This construction is modified to suit the internal planning and at points larger units at 14ft 3in centres are used.



South-east elevation of the office building nearing completion at Stanlow refinery

Services

Fresh air for ventilation purposes is admitted into the system through an intake over the link to the canteen and ducted down to a plant in the basement where it is filtered and washed before passing through a heater battery of finned tubes. The warmed clean air is delivered by a centrifugal fan of 75,000 cubic feet per minute capacity through vertical ducts in the cores to horizontal ducts over the corridors from which the air enters the offices through high level louvred grilles placed at the centre of each module. Air is extracted through low level partition grilles and then through horizontal ducts into vertical ducts to two 28,000 cubic feet per minute exhaust fans mounted in chambers at roof level. There is an average of four changes of air per hour, the number of changes varying according to the purpose to which the space is put, the cinema having

ten changes per hour. No provision has been made for refrigeration but the air washer will provide some degree of cooling. Separate inlet and exhaust ventilation systems, one complete plant for each core, deal with the toilets.

Heating is by hot water radiators, which are hung from the sill beams and cater for all structural heat losses and one-half air change per hour, an arrangement which maintains the building at a reasonable temperature when the ventilation is not in operation. Water for the pumped low pressure system is provided by a calorifier rated at 2,500,000 B.Th.U. per hour at 180 deg. Fah. There is also a 400-gallon hot water calorifier able to raise the temperature of 200 gallons of water per hour from 50 deg. to 150 deg. Fah. for washing. Steam supplies are piped from the refinery. Extensive use is made of polythene piping for the cold water supplies.

Lighting is by fluorescent tube, there being one 5ft tube per module to give an intensity of 15 lumens per square foot in the offices. In the drawing offices continuous runs are arranged to provide 50 lumens. In addition to telephonic communication each floor is served by one of three lines of a "Lamson" pre-selector airtube system. For every 500 square feet of floor area there is a "Pearson" metal strip fire detector which when heated expands to close an electrical circuit and give warning, while in the corridors the "National" tubular detector is fitted consisting of a small diameter copper tube containing a fluid which reacts to any rise in temperature.

The canteen building, has an area of about 15,000 square feet, is carried on piles, and has a constructional frame mainly of *in situ* reinforced concrete. In both the canteen and the offices wide use is made of finishes made from raw materials produced by the Shell Group.

The architects are Grenfell Baines and Hargreaves and the engineers are Felix J. Samuely and Partners, while the quantity surveyors are C. E. Ball and Partners, and the contractors A. Monk and Co., Ltd.

Boiling Water Reactors

THE U.K. nuclear reactor programme is necessarily restricted in scope, since effort must be directed mainly to early realisation of the most immediately useful kinds of power plant. Among the many interesting varieties of reactor for which there has not been room in the British programme is that which boils its aqueous moderator in the core and supplies the steam to conventional plant. This deceptively simple conception, which apparently does away with the complication of successive heat exchangers, has its peculiar and difficult problems. Work on such boiling water reactors is being done mainly in the United States, and efforts are also being made in the Soviet Union and Norway. Progress in the various undertakings was reported at the second United Nations conference on the peaceful uses of atomic energy,* which was held in Geneva from September 1 to 13. In summing up the conference, Sir John Cockcroft remarked† that the boiling water reactor power stations seemed to be growing in favour.

The problems in boiling reactors include, as well as those of other water-moderated reactors, the question of steam bubbles and their effects on the statics and kinetics of the plant. Largely because of this complication, the physics of boiling reactors plays a specially important part in their development. A paper read to the conference by J. A. Thie of the Argonne National Laboratory, Lemont, Illinois, U.S.A., summarised some of the work done to date, and this is abstracted at length below. We have singled out a few other interesting papers on boiling reactors, and brief abstracts of these also follow.

Statics and Kinetics

Theoretical Reactor Statics and Kinetics of Boiling Reactors. By J. A. Thie (U.S.A.).—The calculation of steady-state characteristics involves thermodynamics, hydraulics, and neutron physics. One of the chief problems is that of obtaining the flow velocities and steam void contents from the geometry and power distribution. Methods of doing this are now well established, and consist chiefly in obtaining the steady-state solutions to equations based on the conservation of energy and mass.

When the bubble radius is small compared with neutron mean free path, the water can be treated as having a continuously variable reduced density in the application of neutron diffusion theory. Where the effect is not negligible, the factor by which the neutron leakage in a given energy group is enhanced over its homogeneous value is found from Behrens's theory.

A quantity having considerable significance in both the design and performance analysis of boiling reactors is the void coefficient of reactivity, $d\rho/d\alpha$. The steam void fraction, α, is defined as :

$$\alpha = 1 - \frac{\text{density in coolant channel}}{\text{density of water at saturation}}$$

Some understanding of the principal effects contributing to the void coefficient can be had from a two-group reflected reactor with a uniform void distribution. The terms in the equation for $d\rho/d\alpha$ have been computed for an experimental loading of the EBWR-1. The experimental value was determined by insertion of styrofoam strips into reactor water of 0·00954 molar H_3BO_3, and was found to be −0·067. This compared with the theoretic value of −0·060. The extent to which neutron spectrum variations contribute to the equation for $d\rho/d\alpha$ depends on the spectral theory being used, but in any event can be estimated from simple considerations.

In general the void distribution is a continuously varying spatial function, and the local effect on reactivity is typically obtained by either multi-group multi-region computing machine calculations, or multi-group perturbation theory. The non-uniformity of the void distribution leads to distortions in the flux distribution, especially for large reactors and/or large void contents. A further complication is the influence of the power distribution. Techniques of solution are, in order of increasing precision : (1) approximate analytical methods ; (2) iteration between hydrodynamic and neutron diffusion theory calculations ; and (3) numeric solution of the simultaneous equations of hydrodynamics and diffusion theory. One of the simplest analytical methods for axial distributions is the quantum-mechanical WKB approximation. A more exact procedure, in which two-group multi-region diffusion theory was used on the "Univac," gave flux distributions by method (2) above. Although the WKB was fortuitously accurate in this case, it is believed that the approximation generally offers at least a simple estimate of flux distortions.

Problems of boiling reactor dynamics fall into categories of : (*a*) response to large reactivity insertions; (*b*) low-frequency phenomena of both the reactor and associated equipment, and (*c*) high-frequency reactor behaviour. (*a*), being common to all water reactors, has had extensive investigation. Some theoretic progress has been made with (*b*). The work here primarily pertains to the third, variously referred to as resonance instability or "chugging."

Extensive experimental data indicate the propensity of boiling reactors to self-induced oscillation at about 1 c/s. It has become convenient to classify the time-dependent reactor power into : (1) stable operation in which the r.m.s. amplitude of the "boiling noise" (i.e. random power fluctuations) exceeds that of any single frequency but is less than the mean power ; (2) oscillatory operation in which periodic fluctuations exceed the noise but have amplitudes less than the mean power ; (3) unstable operation, with fluctuation amplitudes in excess of the mean power.

With a view to describing small-amplitude high-frequency behaviour, the following assumptions are made : (1) only first-order deviations from equilibrium values are taken into account, and (2) effects due to changes in pressure, saturation temperature, coolant velocity and slip ratio are neglected. In regard to the second assumption, these effects can be included by solving additional equations simultaneously with those considered in the paper. Digital or analogue computer solutions of the latter are readily obtainable, but greater insight is had from an analytic Laplace transform solution.

By applying a theoretic approximation to EBWR-1 at 20MW, it was possible to compare with experimental transfer function measurements. The height and width of any resonance found is the only currently acceptable quantitative definition of boiling reactor stability, and therefore the only available stringent test of a theory. It is concluded that the theory is at least qualitatively acceptable, and that progressive refinement will be possible.

A boiling reactor's random power fluctuations are due to heterogeneities in inlet water temperature, local randomness in bubble formation and motion, and random disturbances in external equipment associated with steam and water flow. Whatever the source, when terms giving its frequency distribution are added to the reactor's dynamic equations, the resulting response will be this distribution "shaped" by the reactor's frequency response.

Conclusions.—In reactor statics, proper refinements of established calculating techniques show current reactor theory to have adequate precision. Such relatively simple methods as two-group diffusion theory, perturbation theory, and the WKB method suffice in the solution of many problems associated with steam voids. In dynamics the principal problem is a theoretic understanding of sharply resonant transfer functions found at high powers, and hence an understanding of instabilities. The neutron kinetics equations, solved simultaneously with reactivity feeds-back stemming from fuel temperature and steam voids, are sufficient to describe high-frequency phenomena. An analytic Laplace transform solution is pos-

* See THE ENGINEER, August 29, pages 321, 324 ; September 5, page 380; September 12, pages 398, 408; September 19, pages 434, 442, 445.

† See THE ENGINEER, September 19, page 442.

sible, and in spite of the complex processes, by judicious approximations fairly simple results can be obtained. Agreement with experiment is encouraging. It is therefore now believed possible to design away from instabilities. Subjecting a boiling reactor's random power fluctuations to statistical analysis shows promise of being useful also.

Shorter Abstracts

Boiling Water Reactor Physics. By T. Snyder and J. Thie (U.S.A.).—The static and dynamic problems are mathematically complex. A number of analytic tools and methods has been developed to deal with them. An accelerated convergence code known as BORE provides a three-group, two-dimensional solution of the diffusion problem with a self-consistent moderator density distribution. A simplifying method is to start with the desired power and moderator density distributions and then compute the required control rod configuration. The dynamic behaviour of boiling reactors is described by non-linear equations, but linearised versions used in standard servo theory have led to rather successful predictions.

Operating the First U.S.S.R. Atomic Power Station with the Fuel Channels Working in Boiling Conditions. By A. K. Krasin, A. N. Grigoryants, N. A. Nikolaev and G. N. Ushakov (U.S.S.R.).—The paper describes experience with the 5MW power station that started operation on June 27, 1954. An outline description is given of the transfer of some channels to boiling operation. The experiments on boiling are discussed, and conditions given for reliable cooling with a steam-water mixture. The peculiarities and advantages of boiling reactors are dealt with in relation to non-boiling plants.

Boiling Liquid Pulsation in Nuclear Reactor Channels. By P. A. Petrov (U.S.S.R.).—Periodicities of flow may occur in steam-producing tubes. These fluctuations may be due to the elasticity of the system or to perturbing forces. Both kinds of fluctuation are considered, and the conditions for their cessation are examined.

A 125MW Boiling Water Indirect Cycle Power Reactor. By W. H. Zinn, J. M. West and G. C. Tavernier (Belgium).—Slightly enriched, compressed and sintered uranium oxide fuel is specified in the design described. The fuel assemblies are clad in stainless steel. The pressure in the reactor and primary circuit is 1000 lb per square inch, and this is said to make for excellent operational stability. Secondary steam is produced at 660 lb per square inch and passed through a conventional superheater to emerge at 565 deg. Cent. The net efficiency of the plant is given as more than 37 per cent. The price per kilowatt-hour is reported to be competitive in Belgium.

Stability of Boiling Water Reactors with Special Reference to the Halden Boiling Heavy Water Reactor. By J. A. Fleck and J. H. Husebye (Norway).—Experiments have shown boiling reactors to be self-regulating, but divergent power oscillations may occur under certain conditions. In the analysis presented an attempt is made to take hydrodynamics into account. Ordinary differential equations governing the hydrodynamic variables are obtained by applying the integral theorems of hydrodynamics to the boiling length of the reactor and evaluating the integrals approximately. The resulting equations, with the reactor kinetic equations, are then integrated numerically with a digital computer. The stability of the Halden boiling heavy water reactor is examined and compared with that of other types.

Tube Annealing Furnace with Electronic Control

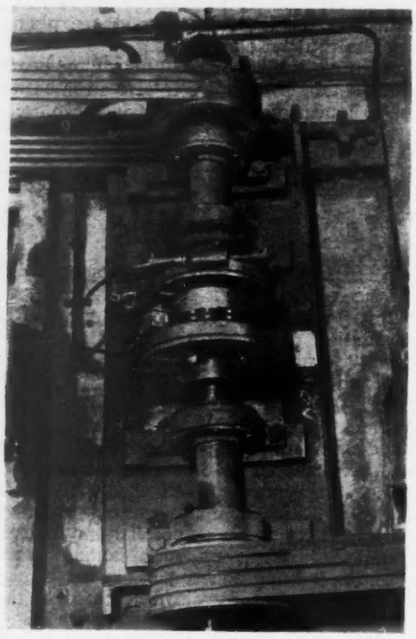
AN electronic control system has been incorporated in a gas-fired, roller hearth annealing furnace recently installed by Birlec, Ltd., in the new stainless steel mill of Talbot Stead Tube, Ltd., Walsall. This furnace is used for the heat treating of stainless steel tubes either on a continuous or batch production basis, and in it use has been made of "Warner" electromagnetic brakes and clutches supplied by Westool, Ltd., to provide overall remote control.

The furnace, which has a capacity for treating 1 ton of steel per hour, comprises four sections: a loading table, a furnace chamber, a spray quench booth and an unloading table, the overall length of the furnace being 165ft. The hearth of each section consists of a series of rollers mounted adjacent to each other and chain driven to enable tubes up to 40ft long and 8in o.d. to be carried completely through all four sections. The furnace chamber, which is pressurised, is divided into four zones, and by the use of specially designed Birlec control valves, the products of combustion form a controlled atmosphere. This produces a controlled oxidation on the surface of the steel, which has the effect of reducing considerably the pickling time.

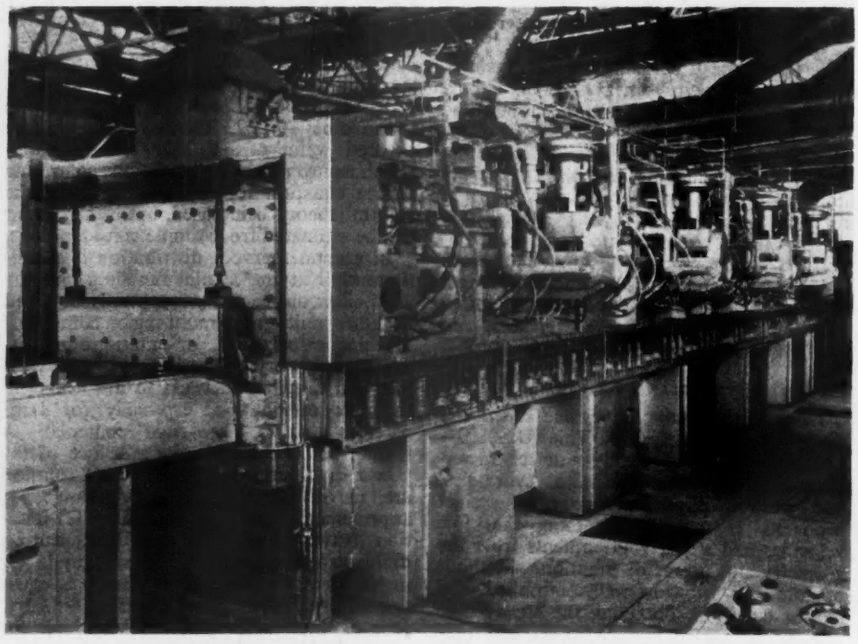
The furnace is controlled from three desks: the main sub-contractor for the control gear was Teledictor, Ltd., and this firm was also responsible for the design and construction of the electronic counting equipment and other apparatus. By means of the control gear fitted, six clutches and two brakes allow the whole furnace to be remotely controlled to a given operating sequence. A clutch and brake shown in one of our illustrations couples the main 12·5 h.p. motor to the main roller drive shaft on the loading table, through a variable speed gearbox. This shaft is, in turn, coupled to the roller driving shaft of the furnace chamber by a clutch coupling. A further clutch couples the furnace chamber shaft to the roller drive shaft in the spray quench section and this shaft is coupled to the shaft on the unloading table.

A 1 h.p. motor with a reduction gear is coupled by a further clutch to the roller shaft in the furnace chamber. This second drive enables the rollers to be driven backwards and forwards during the heating process to avoid distortion within the furnace. A clutch coupling with a brake is fitted to the output shaft of a 30 h.p. motor and when this clutch is engaged to the roller drive shaft of the spray quench section the spray quench rollers are driven at a high speed.

One of the biggest problems which had to be faced on this installation was the fact that during the acceleration and deceleration of the rollers in the individual sections, it was essential to avoid the rollers skidding and, consequently, scoring the tubes. The roller system in each section called for a high starting torque, but once the



Electromagnetic clutch and brake assembly through which the 12½ h.p. motor transmits its power via vee ropes to the variable speed gearbox



Inlet door end of the roller hearth annealing furnace, from the drive side

rollers begin to revolve the driving torque falls to approximately 50 per cent of the starting torque. To provide for this, it was necessary to introduce an electronic closed-loop servo controlled system for the main drive and the high-speed drive clutches so that at all times the rollers were accelerated and decelerated at a controlled rate to prevent a tube skidding on the rollers. All the other clutches revolve at very slow speeds and are controlled by preset potentiometers to give the optimum driving torque and protect the drive chains, &c.

The whole furnace is automatically controlled to provide either continuous or batch production. During continuous operation, the clutches of each of the four sections are engaged to enable the main clutch to drive the whole furnace so that the tubes are continually passing through. In batch production a complete automatic sequence is established. In batch production tubes which have been placed on the loading table are driven into the furnace chamber by engaging the main drive clutch and also the furnace clutch. When the tubes have moved into the furnace, an electronic counting device causes the drive to be stopped. An automatic sequence is now started which causes the oscillating drive clutch to be engaged and the motor started. This drive causes the furnace rollers to be turned backwards and forwards a predetermined amount by the reversing of the oscillating motor. Whilst the tubes are in the furnace, a second batch can be placed on to the loading table.

When the correct time has elapsed, the operator engages the high-speed clutch, together with the furnace and spray quench clutches, so that the tubes are rapidly withdrawn from the furnace and deposited in the quench section. The counting equipment operates as before to stop the drive when the tubes are in the correct position for quenching. The tubes on the loading table can then be run into the furnace chamber for the next cycle. After quenching the tubes are driven on to the unloading table by engagement of the high-speed clutch and motor.

Whenever the main clutch or high-speed clutch is engaged, an electronic servo arrangement comes into action, which allows controlled acceleration and deceleration to be achieved irrespective of the load which the clutch has to work against. Normally, on any movement the sequence is that the load is accelerated to full speed in a period of between five and ten seconds. It then moves to a position just short of the required distance when it decelerates to a very slow speed, at which it moves forward to its final position.

Sea Trials on Channel Power Cable

SEA trials in mid-Channel were started last Monday to take one stage further the proposal to link the British and French electricity supply systems by a submarine cable. This work for the Central Electricity Generating Board is being undertaken jointly by two British companies, British Insulated Callender's Cables, Ltd. and Siemens Edison Swan, Ltd. All being well these sea trials should be completed in ten days.

It will be recalled that the cross-Channel electricity supply link is intended for the exchange of power at peak load periods between Great Britain and France. The link is to be effected by d.c. submarine cable* using two single-core cables to carry up to 800A go and return, at a conductor-to-conductor voltage of 200kV, d.c. This project is sponsored jointly by the Central Electricity Generating Board and Electricité de France and the manufacture and laying of the cable is to be shared by French and British cable makers. The cost of the cable link including the shore terminations but excluding the overhead line connections to the supply systems will be of the order of £4,000,000. It has been estimated that the annual saving to both countries will be about £300,000† because of the reduced requirement for generating plant, bearing in mind the known differences in the incidence of peak loads in the two countries.† We learn that after the end of the British sea trials a consortium of four French cable makers will begin their own trials on the cables which they are to supply for the link.

The sea trials are conditioned by the decision to use separate go and return cables, each carrying 800A d.c., which would cause interference with ships compasses if they were laid more than a few feet apart; a maximum spacing of 10ft has been stipulated.

Accordingly the main purpose of the trials is to confirm the technique of laying two cables simultaneously, separated by not more than 10ft, at a depth of 18 to 19 fathoms. Secondary aims are to confirm the technique for picking up and repairing these cables by the jointing in of new lengths and to derive the maximum of information from electrical and physical tests made during the trials, and afterwards in the two companies' laboratories.

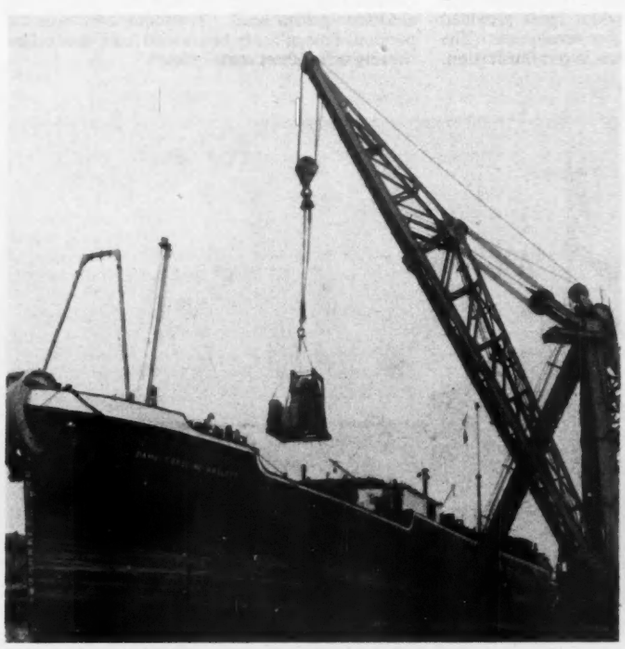
The ship chosen for this operation is the motor ship "Dame Caroline Haslett", a 2700-ton collier of the "up-river" class which is owned by the Central Electricity Generating Board. Various modifications have been carried out by the Board and in addition the ship has been equipped with special paying-out and handling gear (as illustrated) designed to equalise the tension and thus ensure simultaneous laying of the two cables with the required maximum separation. This and other gear including cable test equipment is now installed on the "Dame Caroline Haslett" which has been undergoing fitting out at Woolwich since September 8.

Cables of essentially similar make-up but with minor variations will be used for the two 880 yard lengths that will constitute the "go" and "return" paths for the trials. In each case the cable conductor will be stranded copper of 0·525 square inch section, insulated with impregnated-paper solid dielectric to operate at 100kV d.c. from conductor to earth. In one cable the radial dielectric thickness will be 0·05in greater than in the other. The lead sheath will be protected from corrosion by a sheathing of rubber in the one case and of a plastics material in the other. Both cables will be provided with mechanical protection by galvanised steel wire armouring; on the two cable lengths there will be a small difference in the "lay" of the armouring wires to provide information about the behaviour of the cable during laying and so allow the optimum design to be determined. Both lengths of cable will be served with an overall covering of impregnated jute; the overall diameter will be 3·07in and the weight per yard 36 lb. The two British companies have each manufactured one 880 yard length and one 200 yard length of cable for the trials.

The programme of sea trials will begin with the simultaneous laying of two 880 yard lengths of cable. An explosive charge will then be detonated to sever the cables, after which the severed ends on each side will be brought to the surface in turn and two 200 yard lengths jointed

* THE ENGINEER, September 7, 1956, page 323; September 13, 1957, page 391.

† Sayers, Laborde and Lane, THE ENGINEER, April 2, 1954, page 493.



The collier "Dame Caroline Haslett" being fitted with paying-out gear of special design for laying two submarine cables simultaneously, not more than 10ft apart. Sea trials are now taking place on two 880 yard lengths of 800A, d.c. cable designed to form the basis of a 160MW, 200kV submarine cable link between Great Britain and France

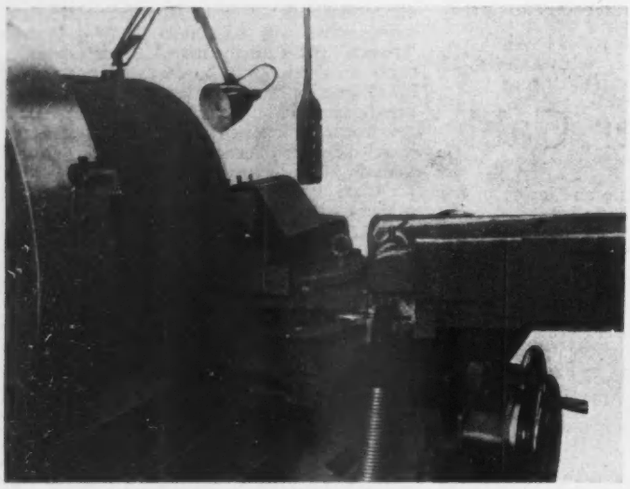
in. The distant ends of the original cables will be jointed together to form a loop for the electrical tests which will then be carried out. These tests will include continuity and insulation tests and a high-voltage insulation test at ±300kV. Finally the whole of the cable will be recovered and subjected to critical tests and physical examination in the companies' laboratories.

During the trials use will be made of a midget submarine supplied by the Compagnie pour l'Exploitation Internationale des Procedes Rebikoff, and skin divers of the Societé Generale de Travaux Maritimes et Fluviaux. The submarine and the divers will be employed in inspecting and taking ciné films and still photographs of the various stages of the underwater operations, and checking the cables separation.

The programme for the sea trials began with loading of the cable and joints at Woolwich on September 19, followed by collection of the French underwater equipment at Calais and the start of cable laying proper on September 22. It is expected that the final picking up of the cable at the end of the trials will be on October 1, and that the "Dame Caroline Haslett" will return to the Thames for discharge by October 7.

Heavy-Duty Lathe

A HEAVY-DUTY, high-speed lathe has recently been built by Denham's Engineering Company, Ltd., Halifax, and installed in the works of Swan Hunter and Wigham Richardson, Ltd., for turning and profile boring large marine diesel engine piston heads. The machine is shown in the accompanying illustration undergoing acceptance tests in which a 670mm piston head was turned and bored whilst mounted in the 36in independent four-jaw chuck. It is fitted with a special saddle on which either hydraulic copying slides or a set of standard compound tool slides can be mounted. When not turning piston heads, the lathe can be used for work up to 7ft long between centres.



Heavy-duty lathe fitted with copying equipment for profile boring large diesel engine piston heads

The headstock is driven through a multi-plate clutch by a 30 h.p. reversing motor, controlled by an automatic star/delta starter. An ammeter is mounted on the headstock and the motor is fitted with "plug" braking. The gearing provides a range of eighteen spindle speeds, from 304 to 6 r.p.m., and the spindle is mounted in specially paired ball and roller bearings.

The bed is of heavy, rigid construction, with chip chutes to the rear for swarf removal and sunk narrow guides for the saddle. Enclosed copper busbars and collector gear are fitted at the back of the bed, with a travelling contactor panel.

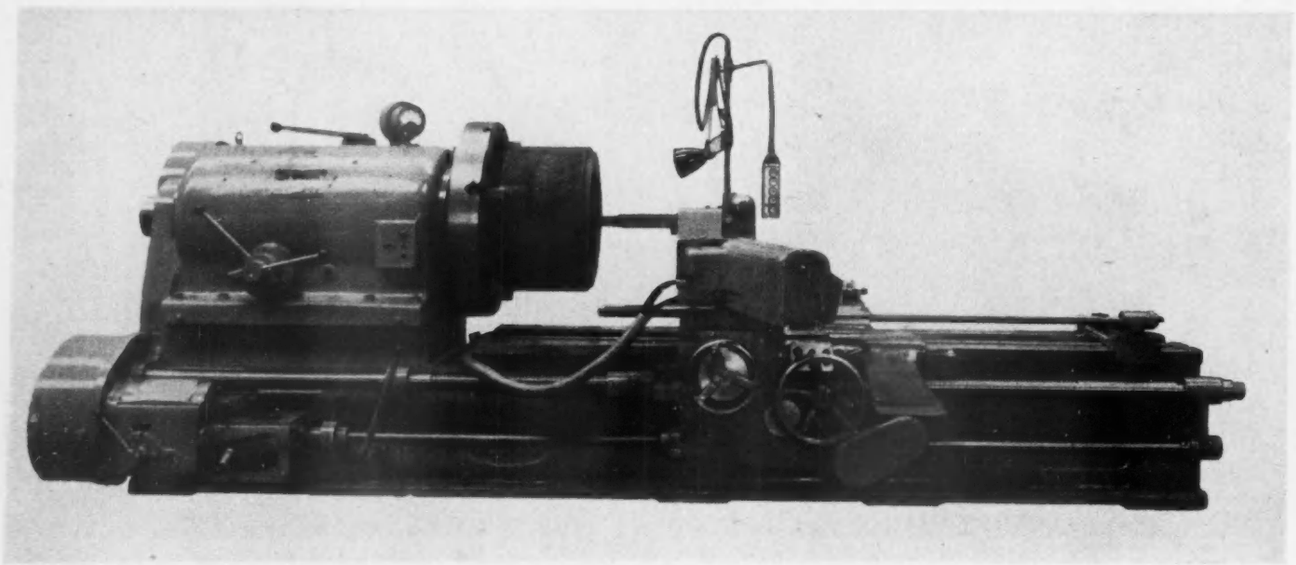
The carriage comprises an apron, with a single lever for engaging the longitudinal and cross traverse feeds, and a saddle on which the copying equipment slides or compound tool slides can be fitted. A range of fifty-four feeds provided is from 0·002in to 0·125in per revolution. The copying equipment can be seen in our illustration.

The main swivel slide of the hydraulic slides can be adjusted through 360 deg. on the cross slide and it provides an anchor point for the hydraulic piston of the equipment. The copying slide which moves on the swivel slide carries the hydraulic cylinder and tracer valve assembly. A swivel race on this copying slide carries an auxiliary swivel slide, which can be positioned radially to set the tool slide in line with the centre line of the machine, irrespective of the setting of the main swivel slide. The tool slide which has a movement of 4½in on the auxiliary slide is bored to take a range of special boring bars and has a tool holder block for standard tools.

In the hydraulically operated tracing equipment there is a 4½in diameter by 10in stroke piston/cylinder unit controlled through a valve block by a lever tracer valve. For profiling operations, on piston heads, the best conditions are given by a slide setting at 70 deg. to centre line and the templates are mounted on a carrier located by a taper strip in a double-vee recess in the cross slide. During profiling the end of the template carrier is secured longitudinally to a bracket locked to the lathe bed, the bracket having an anchor point which is adjustable across the bed to align the clamping of the template carrier parallel to centre line. With a longitudinal feed engaged the carrier (and on it the template) remains stationary, whilst the stylus traverses with the carriage and, through the medium of the tracer valve, moves the copying slides to produce the required form.

The controls of the machine have been specially arranged to assist the operator, for whom visibility of the cutting tool, combined with access to the controls, would otherwise have been very difficult. For moving the saddle during setting and operation, the rapid traverse drive has been set for a rate of 1in per second, to give sensitive movement. An additional position has been provided at the back of the saddle for operating the cross-traverse screw, so that when the operator is leaning forward to see inside a piston head he can still reach the control handle. The push-buttons on the headstock for the main motor drive are duplicated on the saddle, together with rapid traverse push-buttons which are also available in a pendant mounting.

Laminated plastics templates have been provided for use with the tracing equipment by the manufacturers of the lathe, and the boring toolholders used on the machine are high-duty iron castings stressed by steel plates to damp vibrations. It is stated that with this machine a floor-to-floor time of twelve hours can be obtained by a trained operator when machining a 670mm piston head. This compares with the previous time of thirty hours with hand-controlled turning using sheet metal gauges.



Carriage of heavy-duty lathe showing copying slide arrangement

SHORTER REPORTS

Diploma in Technology

At the end of last week, the National Council for Technological Awards announced the names of the first successful candidates to be awarded the Diploma in Technology (Engineering). Thirty-four candidates have successfully completed an approved four-year sandwich course, comprising study at the Birmingham College of Technology and industrial training with The General Electric Company, Ltd. Twenty-seven of them have reached honours level and one further candidate reached second-class honours level in his final examinations, but has yet to complete his industrial training before conferment of the Diploma can be considered. Five candidates failed and these may take the final examinations once more only before August, 1960, subject to the approval of the College Board of Studies and the continued support of the company.

The Council says it considers these results to be very satisfactory in that of the forty students who took the first final examinations at Birmingham College of Technology, twenty-eight reached honours level, seven followed the honours course with sufficient credit to merit a pass, and only five failed. The subjects of examinations were : electrical engineering, mathematics, human relations and industrial relations, together with two of the following subjects, namely, electrical measurements and measuring instruments, electric power, applied thermodynamics, theory of electrical machines, electronics and telecommunications.

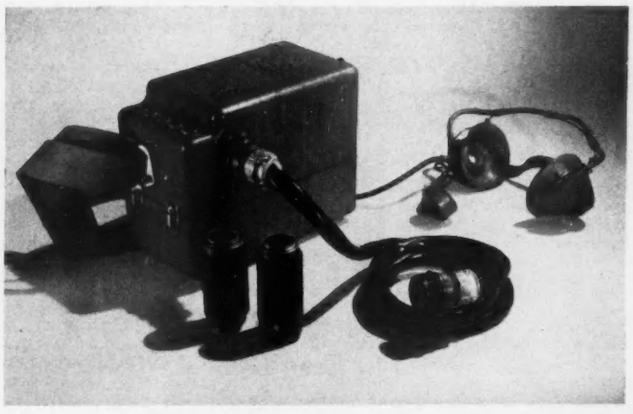
The internal examiners were Mr. C. F. Partridge, vice-principal of the College and formerly head of the department of electrical engineering, and Dr. D. Karo, reader in electrical engineering. Professor J. Greig, of King's College, London, and Dr. E. Glaister, of Imperial College of Science and Technology, were external examiners.

This course in electrical engineering, which was prepared in 1954 by the Birmingham College of Technology, on the initiative of The General Electric Company, Ltd., was designed to meet the needs of industry and full professional standards. When the course was considered in January, 1957, the Council felt that the arrangements proved to be aligned so closely with their requirements that it was only fair for recognition to extend to those students who began their studies on September 1, 1954.

The Council states also that on February 6, last, there were 1394 students attending forty-five courses recognised as leading to the Diploma in Technology. It is hoped that the number of students attending these existing courses will increase this month and again in January next. A further twenty proposed courses have been approved by the Council and the colleges concerned hope that these will start very soon. Thus, it seems likely that by the end of 1961, more than 1000 students will have qualified for the conferment of the Diploma in Technology, and that this figure may well increase to 2000 by the end of 1962. Furthermore, the Council expects that more courses will be recognised during the forthcoming academic year, although some of these will depend on the colleges concerned being able to recruit adequately qualified and experienced teaching staff. The Council feels that the results in the Birmingham course in electrical engineering represent an encouraging start to the Diploma in Technology. The present development of courses, it says, indicates that a promising move has been made towards achieving the aims set out in the White Paper on Technical Education which was presented to Parliament in February, 1956.

Portable Test Set For Multi-Core Cables

Last week we saw a demonstration of a portable test set for the automatic checking of the continuity and insulation of multi-core cable looms. This product of de Havilland Propellers, Ltd., Hatfield, Herts, was originally developed for checking electrical cable systems in aircraft (as shown in one of our illustrations), but it is equally suitable for use in any other installations where multi-core cabling is run in confined spaces.



Test set for automatic checking of continuity and insulation of multi-core cable looms. The set weighs 19lb and is shown here with its connector, termination unit and head set for communication with the remote end via the loom cables

Obvious applications could be found in ships, railways, mines and remote control and communications systems generally.

As illustrated, the equipment consists of the test set (normally battery operated) and its associated connector, termination unit and headset. By connecting the test set to one end of a cable run and terminating the far end by the terminal unit, a check can be made, in turn, of the continuity of each core, or of the insulation between each core and the remaining cores and earth. The terminal unit, which weighs ½ lb, is reversible and the two ends are clearly marked " continuity " and " insulation " respectively to provide the appropriate conditions between the cores for the two tests.

Having selected " continuity " or " insulation " by push button, after having made the corresponding termination at the remote end, the test is initiated by another push button. This operation starts a motor-driven step-by-step selector which applies the test to each wire in turn. At each step of the selector the particular wire under test is indicated, normally by a code letter in a window, which is illuminated by a red light if failure occurs, in which case the selector stops at the faulty core. Successful completion of a test sequence is shown by the extinguishing of a separate indicator lamp. A " reset " button prepares the test set for a further test sequence. The speed of operation by the selector, on continuity, is five conductors per second ; on insulation there is a choice of three speeds, namely, one conductor in thirty seconds, fifteen seconds or six seconds, each conductor being checked to all others bunched and to earth. The insulation test voltage is 500V d.c., which is non-lethal because of current limitation.

The single outlet from the test set can be adapted for use with any cable by means of a suitable coupler which can be supplied against the customer's requirements. In its present form, as demonstrated, the equipment includes a connector (Plessey Mark IV) in which the coding is checked by a clearly marked movable keyway on both the coupler and termination units. Thus, normally the connector provides a capacity up to twenty-five conductors per test, but larger cables can be accommodated by the use of extra adaptors.

To facilitate the testing of long cable runs, where the termination unit at the remote end is conveniently attached by a second operator, intercommunication is provided by headsets. For this purpose a transistor amplifier is built into the test set and the connection for the speech channel between the two operators is made through the cable under test. When this system is in use the operators receive an additional audible signal while each test is being made, and the pitch of the signal changes when a cable fault is detected by the instrument.

The power source for the test set is a lightweight Varley battery having no free electrolyte and sufficient capacity for about sixteen hours of normal use ; the consumption, which fluctuates according to the state of the test, is specified to be less than 30W. The battery can be fully recharged in four or five hours. A charging set can be supplied, built into the transit case, which is used to carry the test set and its accessories. It is so arranged that the act of placing the test set in the case makes the charging connections :

The portable test set for multi-core cable looms is here shown in use during the building of a " Comet " 4 airliner

the equipment includes a meter showing the state of charge and a regulator and cut-out.

By releasing four clips the lower part of the test set, which contains the battery, can be removed. Where a mains supply is available, and is preferred, the battery compartment can be replaced by a similar compartment containing a converter suitable for 110V to 250V, 45 to 65 c/s, single-phase supplies. The mains unit embodies printed circuits developed and made by the de Havilland organisation. The casing of the test set itself is a " Fibreglass " moulding, the overall dimensions being 11in by 6in by 8¼in (28cm by 15·5cm by 21·5cm) and the weight of the test set 19 lb (8·5 kg).

Voltmeter for 1500 Mc/s

THE voltmeter illustrated here is a recent addition to the " TF1041 " series of instruments made by Marconi Instruments, Ltd., St. Albans, Herts. It is a vacuum tube voltmeter (" TF 1041 B ") and it is stated to be the first instrument of its kind with a frequency range extending from 20 c/s to 1500 Mc/s ; its range of measurement is 25mV to 300V, a.c. With direct current it is suitable for measuring voltages from 10mV to 1000V and resistance from 0·02 ohms to 500 megohms. Multipliers can be supplied to extend the voltage range up to 2kV, a.c., and 20kV, d.c.

The probe unit that is used for a.c. measurements contains a disc-seal diode rectifier with a resonant frequency of 3000 Mc/s and a low inter-electrode capacitance—properties which make possible a frequency response that is flat to within 1 dB up to 1000 Mc/s and shows a rise

Vacuum tube voltmeter for frequencies up to 1500 Mc/s

of less than 3 dB at 3000 Mc/s. The probe, small and cylindrical, weighs only 1½ ounces.

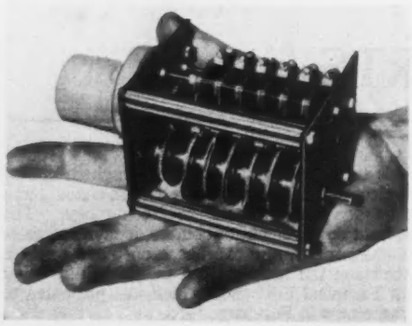
For the d.c. circuit of the voltmeter use is made of a two-stage impedance converter. Each stage embodies two cathode followers and there is heavy degeneration between the input points and the moving-coil meter across the output, to ensure that the accuracy is virtually independent of valve characteristics. On all valves the filament supply is stabilised, and the effects of meter temperature coefficient are offset by a series thermistor. The stability and freedom from drift resulting from these refinements are manifested by a steady zero, which needs only one setting to suit all ranges.

There is no conventional chassis, all components being mounted on the rear of the hinged front panel, and the a.c. and d.c. inputs are isolated from this panel.

On all d.c. ranges, a centre-zero facility is available to aid the precise determination of null point in bridges or discriminators. Measurement of d.c. volts and ohms is simplified by the special dual-purpose d.c. probe with its finger-tip " V/Ω " selector ; set to " V," an isolating resistor is introduced to shield the circuit under test from the effects of probe-lead capacitance. The d.c. supply for ohms measurement is obtained without the use of batteries.

Miniature Cam-Operated Synchronous Timer

THE accompanying illustration gives an impression of a new miniature " MSC " cam-operated synchronous timer made by the Electrical Remote Control Company, Ltd., the Fairway, Bush Fair, Harlow, Essex. The specimen shown here has six cams, each of which is friction mounted on the camshaft ; each cam operates a changeover switch and can be adjusted smoothly to vary the switching time intervals. The camshaft is driven through a friction clutch and gears



Cam-operated synchronous timer. Each cam operates a changeover switch and is friction mounted on the gear-driven camshaft for adjustment of the time interval

by a small synchronous motor for 50 c/s or 60 c/s supplies at 110V, 230V or 440V, as required.

" MSC " timers can be supplied with one to twelve sets of cams and changeover switches, instead of six sets as illustrated. The switching capacity of each circuit is stated to be 10A at 250V a.c. non-inductive, or 6A at 250V a.c. inductive, and the inrush current should be limited to 30A.

The timing range is wide : the final shaft speed can be fixed to give any cycle time between five seconds and twenty-eight days. One of the timer switches can be wired in series with the motor and the corresponding cam can be set to open the motor circuit at a predetermined point in the cycle ; thus, the timer can be used as a hand-set multiple-circuit, multiple-time-interval device.

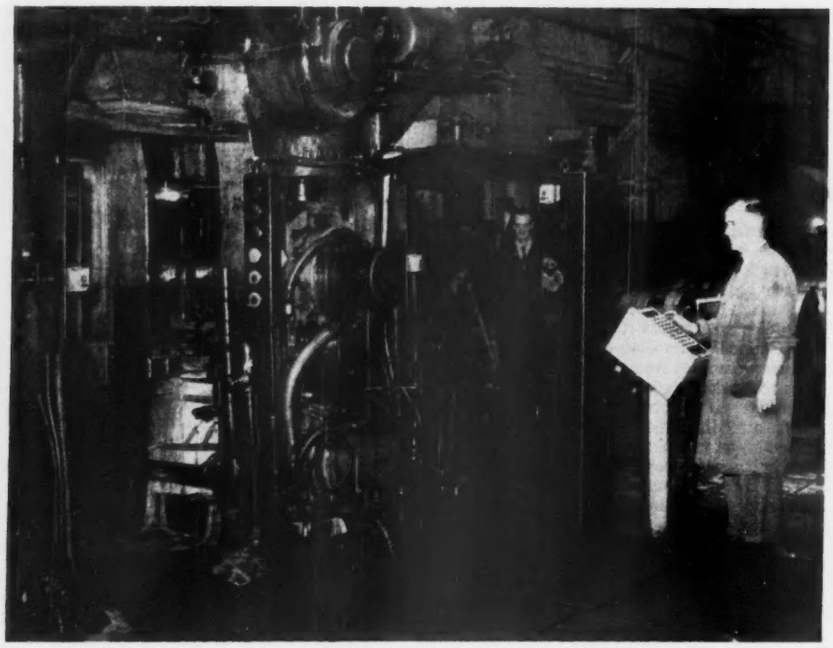
The camshaft is mounted in oil-retaining bearings. At one end the shaft projects through the end plate to allow for hand resetting to zero. With six cams and changeover switches, as illustrated, the timer, including the shaft projection of ¼in, can be housed in a space of 6¾in by 3in by 3in.

Performance Recorder

PRODUCTION planning and costing rely on accurate recording, but the conventional pen-and-moving-chart method suffers from the slowness of the subsequent analysis. With the performance recorder recently developed by the British Iron and Steel Research Association, the machine-operator uses his press-button station to signal data such as shift number, job number, running time, idle time and, by a simple predetermined code, the reason for idle time. The recording apparatus transcribes the incoming electrical signals into punched holes in a multi-track tape, which is then analysed at high speed. Running reports can thus be provided to the administrative centre minute by minute, or a consolidated statement of each shift's activities can be prepared at convenient intervals. Results can be presented either on punched cards or by standard teleprinter. There are three essential elements in the system ; the " press-button " station next to the machine, the central recording apparatus (with its " queueing " device to accommodate a series of simultaneous signals from a number of machines), and the " reading-out " unit in the appropriate office.

Examples of the instrument's use have been described to us by B.I.S.R.A. The first industrial installation was made, by a large South Wales steel works, to monitor eighteen units of plant employed in cold-rolling strip. Another installation is reported to have been made at the Prescot, Lancashire, works of a large cable and wire maker. Here, a single-channel apparatus has been applied to a large machine drawing heavy copper wire for power cables. In the first instance the recorder is being used on works-study investigations, recording facts such as material consumed, machine utilisation and down-time. The tapes are being analysed on the firm's pay-roll computer. Another Welsh steel works is using a recorder to investigate the performance of certain heavy mills on an electrolytic tinning line. The recorder is designed to handle fifty-five different signals, making it possible to record, among other things, the time of day, day of the month, idle and running time, order number, fault number, number of prime grade sheets produced, number of second-grade sheets, number of rejects, power consumption in kilowatt hours, and shaft revolutions on the main drive. A single-channel installation has also been supplied to a Yorkshire manufacturer of steel sections and strip. This recorder has been applied to a cold reversing mill and will probably be the prototype of other installations at the works in the light of experience. The present recorder is being used for cost-analysis

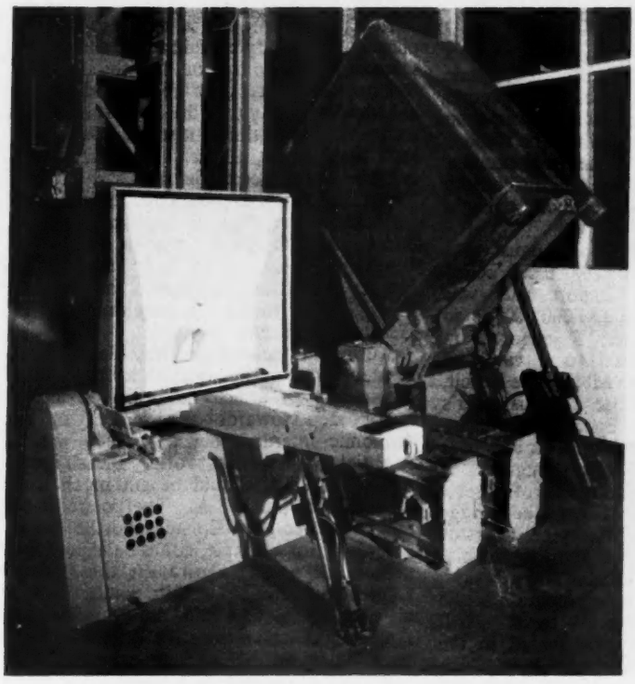
All these performance recorder installations have been made by the Digital Engineering Company, Ltd., Battersea Park Road, London, S.W.11. The apparatus is also being produced by Davy and United Engineering Company, Ltd., of Sheffield.



Station for feeding coded data to the central recording apparatus of a performance recorder. The illustration shows one of eighteen " feeding-in " points at a Welsh steel works producing cold rolled steel strip

Bulk Materials Handling

A DEMONSTRATION of the "Tote" system for the bulk handling, storage and transport of granular materials, powders and liquids was recently given by Pressoturn, Ltd., Leam Terrace, Leamington Spa, Warwickshire, the British licensees for the system. In this system a bin of heavy gauge aluminium alloy, designed for easy handling and stacking by crane or fork lift truck, is used. A 9in diameter filling aperture is situated at the top of the bin and a discharge door 34in long by 14¾in wide is fitted along the lower edge of one side. Each door of the apparatus is sealed against dust and made watertight by specially designed gaskets and fasteners.



Bin unloading equipment. On the left can be seen an unoccupied tilting gear with screw feed on the backplate which controls the supply of material into the process. On the right, a bin is tilted to the discharge angle

The system demonstrated was at the factory of Aspro-Nicholas, Ltd., Slough, and we reproduce a photograph of the bin discharging equipment at that factory. The bins are placed by fork trucks on the base beam of the equipment with the discharge door against a large recessed back plate. Clamping arms then rigidly lock the bin against the plate, the edges of which are sealed by resilient strips against the side of the bin. A key is inserted through a sealed hole in the back plate and fitted on to the discharge door lock. As the bin door is unlocked by the key it moves outwards to seal against a seating formed by a projection round the key orifice in the plate. With the bin discharge door open the whole assembly is then tilted over by a screw jack to an angle of 45 deg., as shown on the right in the illustration. As the bin contents gravitate out of the discharge door they fall into a trough fitted with a screw conveyor along the lower part of the back plate, and this conveyor delivers the material into the boot of an elevator at the side. In this particular case the material being discharged is free flowing but if powders likely to pack or bridge are being handled a vibrator can be readily fitted.

With the method of discharging which has been developed any material carried in the bins is completely sealed to prevent its contamination by airborne dust, or likewise its release to contaminate the surrounding atmosphere. Bins are made in three standard sizes of 42, 74 and 110 cubic feet capacity and their design is such that materials can be stored and transported in them without fear of contamination or loss. They are fitted with cup-ended legs which register in cup pads in the top corners to facilitate safe stacking during storage. The makers point out that where a number of bulk ingredients have to be delivered for processing and mixing in a factory the bins provide a very useful facility for direct delivery batching, in that they can be taken into a plant and discharged into appropriate service hoppers without intermediate handling of materials. If required, batch weighing devices can be fitted in the bin filling or discharging equipments. When very fine powdered materials have to be loaded, a spinner head and jolter can be supplied. The spinner throws the material to the sides of the bin, forming a level load, and the jolter vibrates it to ensure capacity loading. As the bins are weather- and dust-tight they can be stored on uncovered or any available sites without fear of damage to their contents by weather or by evaporation, or attacks by vermin and rodents.

Cellulose pulp on its way from the preparation plant, carried by a moving sheet of fine felt until gathered up by a revolving mandrel

Pitch Fibre Pipe Factory Extensions

PRODUCTION of pitch-impregnated fibre drain and sewer pipes at the factory of the Key Engineering Company, Ltd., Larkfield, near Maidstone, Kent, has recently been greatly increased by the introduction of new plant, a new machine shop and the adoption of a mechanised layout.

Straight pipes are manufactured in lengths of 8ft or 5ft 6in, with internal diameters of up to 6in. The pipe is made from a pulp of a mixture of carefully selected cellulose fibres designed to give the best structure in the finished white pipe. The pulp is fed from the preparation plant on to a moving sheet of fine felt; this can be seen in the illustration. A revolving mandrel gathers the mixture from the felt and builds up the wall thickness of the pipe to the required degree, the size of the pipe being controlled by the length and diameter of the mandrel employed. When the desired wall thickness is reached, the mandrel with its wet fibre pipe is automatically ejected on to a conveyor which feeds the drying ovens, and a new mandrel drops into position in contact with the felt. The wet fibre pipes travel on slow-moving conveyors through the drying ovens, where the humidity and temperature are rigidly controlled, until they emerge baked into a hard, tough condition. The mandrel is then automatically ejected and returned to begin its cycle of operations over again, whilst the now dry pipes are carried in batches by crane to the impregnation section. Here they are subjected to alternate vacuum and pressure impregnation cycles with pitch maintained at a preset temperature, the pitch soaking right through the wall of the pipe, making a homogeneous structure of great strength. After being cooled, the pipes are taken to the machine shop, where a 2 deg. taper is machined at each end by automatic lathes. Pipe bends, junctions, angled couplings and adapters are also made in the factory, as well as saddles and adapters for jointing fibre pipe into other types of drain pipe.

Work on a conveyor system at the end of the factory, which will carry the finished product to the stockyard for distribution and stacking by fork lift truck, is still being carried out.

Medical Electronics Discussion Group

WITH the encouragement of members of the medical profession, the Council of the Institution of Electrical Engineers has instituted a Medical Electronics Discussion Group, to provide a forum in which electrical engineers specialising in electronics can meet members of the medical profession to discuss problems in which they have a common interest. This group will hold regular meetings having the nature of colloquia, at which subjects coming within the field of medical electronics will be discussed. The affairs of the group will be guided by a committee broadly representative of members of both professions who are prominent in this field.

Any person interested in these activities should send his name and address to the Secretary of the Institution of Electrical Engineers, Savoy Place, W.C.2, for inclusion in a mailing list which is now being compiled.

With the object of supporting the second International Conference on Medical Electronics which is planned for next year, the I.E.E. Council has agreed that the committee of the new group should receive, on behalf of Dr. C. N. Smyth, M.A., B.Sc. (Eng.), M.B., B.Ch., M.I.E.E. (a vice-president of the Interim Committee of the International Conference and Chairman of its Papers Committee), notice of any papers coming from British sources.

Industrial and Labour Notes

Miners' Wages

Two days last week were taken up in discussions between the National Coal Board and the National Union of Mineworkers on a claim for a wage increase for day men. The claim submitted by the union was for an increase of 15s. a week ; it followed the rejection, by the Board and by the industry's arbitration tribunal, of an earlier claim for 10s. a week.

At the end of the talks on Thursday of last week, it was stated that the union executive had agreed to recommend to a conference of union members on October 1 acceptance of an increase of 7s. 6d. a week in the basic grade rates of day-wage men, with proportionate increases for juveniles. Consequential increases for craftsmen, winding engine men and weekly paid industrial staff, it was explained, would be negotiated between the Coal Board and the union in the next few days. A statement, agreed by the Board and the union, explained that the Board's offer of increased wages would be subject to acceptance by the union of a standstill in pieceworkers' rates for a period of nine months and of a resumption during the winter months of voluntary Saturday working at pits which produce a high proportion of large coal. The standstill on pieceworkers' rates, the statement continued, would not affect claims for increases already submitted or claims in respect of changed methods or conditions of working. As to Saturday working, the Board would consult the union as to pits where it would be advantageous for it to be introduced. Finally, the statement said that the Board and the union would set up machinery at national level to secure that effective joint action was taken " to remove impediments to operational efficiency."

The Civil Service

The report of the Civil Service Commissioners for the year ended March 31, 1958, says that the total number of candidates dealt with in that period was 111,702, compared with 112,590 in the preceding year. The number of successful candidates in competitions rose from 11,606 to 13,057, but, the report observes, in most of the main classes of the Civil Service there were more vacancies than suitable candidates.

In the section of the report which refers specifically to the scientific classes it is noted that, although the number of applicants in the senior scientific officer competition was noticeably less than in 1956, most of the vacancies declared by departments were filled. One observation made by the Commissioners is that at scientific officer level the average quality of the candidates was not so high and the results were therefore less satisfactory. The report goes on to say that there is " little change to report on recruitment to engineering posts." During last year there was a decrease in the number of applications and most of those received were from candidates serving in temporary posts in the Civil Service, to which they were appointed by *ad hoc* departmental recruitment. The major result of the competitions has therefore been the establishment of temporary staff rather than the introduction of fresh recruits. The Commissioners point out that, in a period when the volume of engineering work has shown a tendency to contract in some Government departments, there is naturally a strong incentive for temporary officers to seek establishment. But they go on to say that the continued lack of well-qualified young entrants increases the anxiety, first expressed two years ago, as to future leadership in so important a field. From the numerical point of view, the Commissioners add, the most serious shortages are still of civil and electrical engineers, particularly of electrical engineers with a knowledge of communications.

Overseas Trade

In its survey of the United Kingdom's overseas trade in August, the Board of Trade says that the final figures for both exports and imports were substantially lower than those for the preceding month. The reasons given are the beginning of the usual summer quiet period of trade and the end of recovery from delays, caused by the dock strike in June.

The value of exports in August was £257,800,000, which was £28,000,000 below the July total, and the import value was £304,300,000, which was £33,000,000 or so less than the July figure. Re-exports, on the other hand, increased to a value of £13,100,000, so that the visible trade deficit, at £33,400,000, was close to this year's monthly average. The Board's survey includes some comments on export trends over the last three months (June to August). It is explained that the monthly rate of exports in this period was 7 per cent below the average of the earlier months of this year. Part of the decline is attributed to the normal seasonal movement, but, the Board says, " there was clearly also a continuation of the recent underlying downward trend." All the main groups of exports shared in the decrease, including engineering exports, which until recently have constituted much the most buoyant sector. Exports of engineering goods in the June–August period were 5 per cent below the January–May rate, machinery other than electric falling by 8 per cent, electrical machinery by 7 per cent, cars and chassis by 7½ per cent, and commercial vehicles by 16 per cent. At the same time, aircraft exports were 11 per cent more and those of ships and boats increased by 66⅔ per cent. Exports of metals between June and August were 11 per cent below the January–May level, with a fall of about 20 per cent in the shipments of iron and steel, but no overall change in the value of non-ferrous metal exports.

British Agricultural Machinery

At the annual conference of the Agricultural Engineers Association, which was held at Selsdon Park, Croydon, last weekend, one session was devoted mainly to a discussion of the influence of a Common Market and of a European Free Trade Area on this country's extensive agricultural tractor and machinery industry. The subject was introduced by Sir Norman Kipping, director-general of the Federation of British Industries. A great deal of Sir Norman's speech was " off the record," but in answering the many questions that were put to him, he dealt very ably with a number of problems which have to be considered in connection with the probable development of a European Free Trade Area. The topics touched upon ranged from tariffs and transport to trade fairs.

The president of the Agricultural Engineers Association, Mr. Lionel Harper, who was in the chair at the conference, said that from a tractor manufacturer's point of view the picture of a free trade area was " far from disheartening." The free trade area would be composed in the main of countries that were traditional markets for Germany's engineering products. Both the United Kingdom and Germany, however, had increased their tractor sales in the area by 25 per cent ; this country's annual share was now £16,000,000, against Germany's £11,000,000. It would be wrong to be complacent, Mr. Harper commented, but there seemed to be no reason for the trend of tractor sales to alter to Britain's disadvantage. He went on to say that the figures for implement sales told a different story. During the last three years, British farm implement exports to the free trade area had risen by 22 per cent to just £4,000,000 a year, but over the same period German implement exports had increased by 38 per cent to £18,000,000 annually. That could only mean, Mr. Harper added, that Continental farmers were using British tractors in conjunction with German equipment.

During the conference, Mr. Harper commented on the relaxation of restrictions on dollar imports which he described as " a major step towards achievement of the economic interdependence " which was so essential to the western world. British industry, he thought, should benefit much more than that of the U.S.A. The possibility of more trade between Canada and the United Kingdom, for example, could be expected to produce a greater desire on the part of Canada to purchase British goods. Above all else, Mr. Harper said, the availability of American machine tools for British factories would enable the agricultural machinery industry to increase its efficiency still more and thus maintain its prices as it was doing at the moment, despite rising costs.

Moving from London

The London County Council has arranged, at Charing Cross Underground Station, an exhibition entitled " Moving from London." It has been designed to demonstrate the advantages which industrial firms may derive by moving from London to expanding country towns where factory sites are available and new houses are being built for employees. Development in country towns is already planned to provide 16,000 homes and jobs for Londoners in Bletchley, Bury St. Edmunds, Edenbridge, Haverhill, Swindon, Thetford, Aylesbury, Huntingdon and Letchworth. Negotiations with Ashford and Basingstoke are proceeding.

The exhibition was opened on Monday by the Minister of Housing and Local Government, Mr. Henry Brooke, who praised the efforts of the L.C.C., in co-operation with other local authorities, to encourage the movement of factories, offices and people out of overcrowded London. Recently, the Minister continued, there had been a conference about offices moving out of London ; the exhibition, however, concentrated on factories. Many firms, of course, had moved their factories to new towns. Now there were existing country towns which wanted more people to come and live in them under agreements made with the L.C.C. These towns had the space to put up modern factories with room to expand and to provide better housing as well as quick and easy journeys to work.

"Mecanelec 58" Exhibition

No. II—(*Concluded from page 466, September 19*)

AMONG the exhibits shown in the heavy machine tools section we noted presses by Etablissements Georges Bret, Verneuil-sur-Avre (Eure). These included inclinable and fixed gap presses, die presses, press brakes, billet shears, and guillotine shears. The presses are equipped with electro-pneumatic controls, the guillotine shears with hydraulic hold-down, while a motorised rear guide with optical indicator enables all adjustments to be made from in front of the machine.

Société de Constructions de Montbard, 6, Rue Daru, Paris (8e), showed straightening roll stands with crossed hyperbolic rolls. One twin-roll machine was the model VBM 120 for straightening bars or heavy tubing of 40mm to 120mm external diameter (mild steel) at up to 30m per minute. The range of machines covers diameters of 6mm to 406mm (8mm to 250mm for the twin-roll machines).

H. Ernault-Batignolles, 169, rue d'Alésia, Paris (14e), showed the "S-Pilote" automatic copying lathe for diameters up to 455mm and maximum turning length of 500mm or 1000mm. Normally fitted with a 15 h.p. motor, the lathe can be equipped with motors up to 30 h.p. Built for large or small batch production, the machine is programmed by means of perforated cards printed in "clear" without the use of any code.

Société Alsacienne de Constructions Mécaniques, Graffenstaden (Bas Rhin), showed the AM.133 horizontal boring mill with 130mm diameter spindle, a development of the AM. 131 (2000mm vertical travel, 4000mm traverse, 21 h.p.). This machine has been equipped with hydraulic controls. The heavy milling machine FH 142, by the same maker, is arranged for automatic cycling. Fitted with a 32 h.p. motor, it is designed for normal or climb milling.

Covema, 15, rue de la Nouvelle France, Aubervilliers (Seine), showed an improved version of its model A3 horizontal boring and milling machine. This machine has a 1500mm long horizontal bed (special size, 2100mm) similar to that of a lathe, with lathe-type saddle actuated by lead screw and feed spindle. The headstock is mounted on a vertical slide giving a movement of 280mm. The saddle is equipped with a 710mm by 400mm worktable with 335mm transverse and 850mm or 1450mm longitudinal movement, depending on the length of bed. Standard spindle speeds are from 26·5 to 2000 r.p.m., other ranges being available. The tail support for the boring bar has been equipped with a split bushing clamped by means of an eccentric.

The general tendency towards programme control and automatic operation was exemplified by the "Codimatic" lathe shown by Société Nouvelle Henry Hamelle, 21–23, Boulevard Jules-Ferry, Paris (XIe). This machine is electro-hydraulically controlled from a separate cabinet, on the panel of which the programme is set up by means of jacks. For programme repeats, perforated cards facilitate this operation. The speeds and feeds required in the various steps are set by means of dials placed below the programme panel. The lathe has front and rear longitudinal slides, each equipped with independently operated cross-slides which can be set at any angle. In addition there is a central turret slide with hexagonal turret. Slide movements are limited by stops, for the turret these are carried on a synchronously indexing drum. Maximum length of workpiece, 750mm; swing, 400mm; horsepower of motor, 15 h.p.

Several makers showed lathes in actual operation with ceramic cutting tools. One of these was the "Supercap" (below) by Etablissements Sculfort-Fockedey, Vautier et Cie., Maubeuge (Nord), which has a swing over the bed of up to 40½in and is made to admit up to 315in between centres. This latter was demonstrated machining 45-ton steel initially of 260mm diameter, at a spindle speed of 354 r.p.m. (surface speed 250m per minute), with a cutting depth of 6mm and feed of 14mm per revolution. The lathe was equipped with a 40 h.p. motor (Agent: Rudolph Carne and Co., Ltd., Swan Works, Fishers Lane, Chiswick, W.4).

Much attention was caused by a range of heavy programme-controlled copy-milling machines, originally developed for the aircraft industry by Forest et Cie., 16, rue de la Paix, Paris (2e), and now to be built at a factory at Capdenac (Aveyron), specially erected for this purpose. (Sales agent: Ets. Ribail, 71, Boulevard de Reuilly, Paris 12e). Our illustration, below, shows one of these, the model V800 AC2 vertical copy milling machine, with a table of 2800mm by 800mm working surface and 2500mm longitudinal travel (greater lengths available on request). The headstock console has a horizontal travel of 800mm and the headstock itself a vertical travel of 550mm. Feeds are infinitely variable from 15mm to 1500mm per minute under electronic control, and there are quick horizontal and vertical movements of 3000mm and 1500mm per minute respectively. The main motor is of 10 h.p. or 20 h.p. and drives the headstock spindle at sixteen speeds from 20 to 1500 r.p.m., the speeds being hydraulically selected. The feeds are engaged electromechanically by multi-disc clutches; the machine can be arranged for climb milling. All controls are from the front of the machine, which is centrally lubricated. Shown here with copying arrangement for the rapid production of dies or light alloy components (such as are used for aircraft), this milling machine can also be supplied with automatic sequencing of operations.

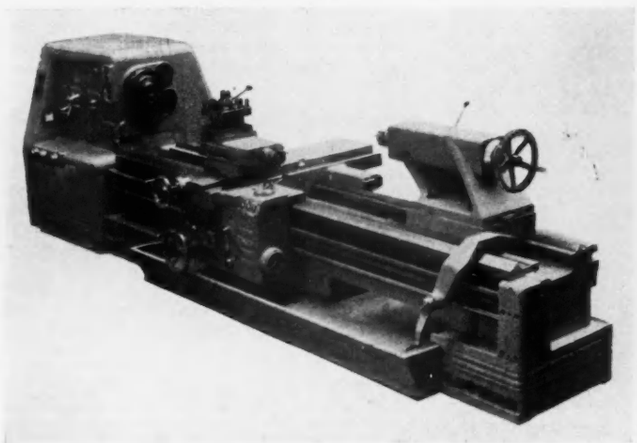
Besides a smaller version of the same machine, Forest et Cie., were showing heavy horizontal millers with table sizes up to 5200mm by 800mm (standard, 2800mm by 800mm and 2200mm by 500mm). These can be supplied with horizontal, vertical or transversal copying device and motors of 15 h.p. to 50 h.p.

Ateliers G.S.P., 138, Bd. de Verdun, Courbevoie (Seine) (Stanhope Machine Tools, Ltd., 202, Acton Lane, London, N.W.10) are putting on the market a gear hobbing machine for straight or helical gears up to 450mm diameter (or lengths up to 250mm) and module 10. Equipped with a 15 h.p. motor, the machine takes hobs up to 150mm diameter by 160mm length. Milling speeds range from 75 to 495 r.p.m. The gear blank is carried on a vertical horizontally adjustable work spindle while the hobbing cutter together with the whole of the headstock is situated on a vertical faceplate which can be rotated about a horizontal axis and set to the required angle with optical indication. The machine is push-button controlled from a panel and can be equipped for automatic cycling. For helical gear-cutting, the inclinable cutter slide travels at an angle parallel to the tangent of the generating helix, thus eliminating the classical differential. Feeds and quick return motions are hydraulic.

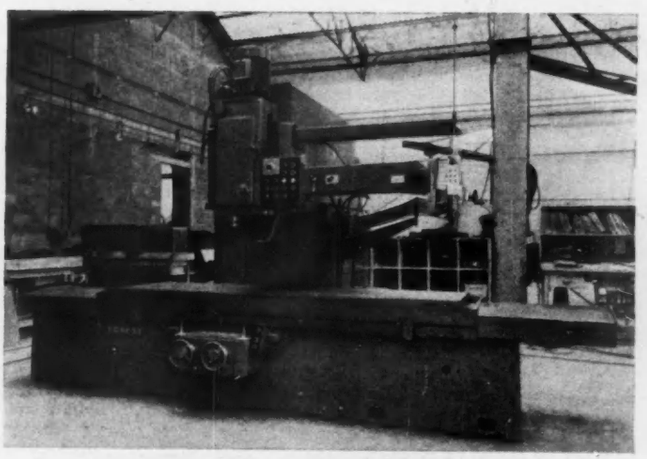
A portable nibbling machine for light and heavy tubing and for sections was shown by Protechno, 179, rue des Fauvelles, Courbevoie (Seine). The machine is hand-lever operated and mounted on a tubular stand. It is produced in two versions suitable respectively for diameters of up to 33mm to 42mm and 50mm to 60mm, and weighing 40kg and 70kg. In the heavier machine, a pawl-and-ratchet double purchase device can be utilised for cutting thicknesses up to ¼in, while the smaller machine will cut up to ¼in. Designed principally for cutting out the ends of tubes in preparation for welding or brazing two tubes at right angles, the nibbler can also be fitted with cutting tools producing rectangular and rounded notches and slits, and splayed ends for grouting into walls. All tools are rapidly interchangeable. It is claimed as a special feature of the cut when trimming tube ends, that only the saddle surfaces are cut to the correct radius, the lateral jaws being left uncut so as to prevent the formation of thinned lips there which are easily burnt in the subsequent brazing.

For the resharpening of tungsten carbide-tipped tools, Diamant-Nickel, 39, rue Sylvain-Royé, Nantes (L.-A.), showed the G.L.C.11 double-ended tool grinder fitted on one side with a diamond wheel for the cutting edge and on the other with a wheel for the chip breaker. The tools can be bolted on the inclinable work support at any angle relative to the wheel. The work table is supported on flexure pivots to allow the tools to be traversed across the face of the wheel without chatter due to stick-slip.

Automation in factories was illustrated, among other equipment, by a Renault transfer line of the kind used in the Billancourt works, comprising the conveyor, turning and machining stations. The latter are equipped with the unit



"Supercap" heavy-duty lathe—Ets. Sculfort

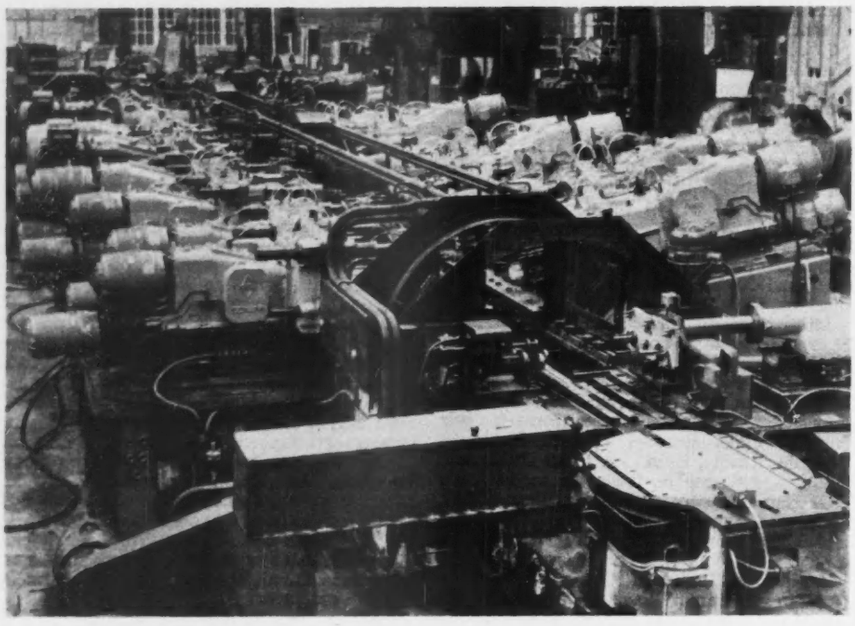


Model V800 AC2 vertical copy milling machine—Forest et Cie

heads introduced and manufactured by the Regie Nationale des Usines Renault (below).

Société des Servomécanismes Electroniques 1^er, rue Chanez, Paris (16e), showed the "Relaistat" system for the automatic control of electrical machinery such as motors, furnaces, and distribution networks. This comprises an assembly of electro-magnetic relays actuated by electronic circuits on the "all or nothing" principle. The control currents are limited to 8V to 16V, 1mA to 30mA, and thus enable this portion of the equipment to be made very compact and reliable, without any moving contacts, actuating the relays by means of magnetic amplifiers.

The machine shown by the Compagnie Parisienne d'Outillage à Air Comprimée (C.P.O.A.C.), 11^bis, rue Roquepine, Paris (8e), illustrated the possibility of converting a manually controlled machine tool to automatic operation



Transfer line for the machining of cylinder blocks—Regie Nationale des Usines Renault

by means of pneumatic and electro-pneumatic devices. In the present case, five milling operations were carried out, involving the three fundamental movements of the milling machine, together with the rotation and inclination of a universal dividing head, all actuated by speed-controlled rams supplied by magnetic air valves.

Among the electric measuring instruments, mention may be made of two novelties put on the market by Chauvin Arnoux, 190, rue Championnet, Paris, one being the "Precitest" universal meter for voltage up to 5000V d.c. and 1000V a.c. currents from 50μA to 10A, and two resistance ranges (ohms and kilo-ohms). The instruments are housed in an unbreakable waterproof plastic case with flexible supports, temperature compensated for −20 deg. to +40 deg. Cent., frequency compensated from 20 to 20,000 c/s, and unaffected by external magnetic fields. The same firm also showed a transistorised capacity meter operated by means of a dry cell, giving measurements from 2pF to 0·1μF.

A.O.I.P., 8–14, rue Charles-Fourier, Paris (13e), exhibited a recording galvanometer for operation from 50 c/s mains, with fourteen paper speeds from 40mm per hour to 3mm per second. The sensitivity of this instrument is quoted as 3×10^{-9}A per millimetre and 2×10^{-6}V per millimetre. Eleven millivolt and micro-ampere ranges are incorporated.

A miniature compensating recording potentiometer was shown by MECI, 123, bd de Grenelle, Paris (15e). This instrument, the "Minipont," has a dial of 190mm by 193mm with a paper width of 177mm, of which a length of 100mm is visible. Up to six channels can be recorded point by point by means of different colours. Paper speeds of 15mm, 30mm or 60mm per hour can be set and the instrument contains a month's supply of recording paper for the intermediate speed. Mains operated, it comprises a mechanical and an electronic chassis. Maximum sensitivity is 2mV full-scale deflection with an accuracy of 0·6 per cent of the full-scale value for mains voltage fluctuation not exceeding ±15 per cent. The commutator switch of the six-position model operates every 2·5 seconds, the time for full deflection being two seconds.

Developments by Rochar Electronique, 51, rue Racine, Montrouge (Seine), include a differential repeater amplifier for angular or linear position. Also shown was a numerical potentiometer, converting d.c. voltages between 0V and 100V into figures, for visual observation or machine or perforated card transcription. Other equipment by the same company included an electronic industrial chronometer counting from 0·1 to 10 seconds at $^1/_{100}$ second intervals; other electronic counting equipment, ultrasonic testing equipment, and "Magnedyne" speed controls.

Several firms showed ultrasonic equipment for non-destructive testing, machining of hard metals, and cleaning of components. The last-mentioned class was represented by a "Cleansonic" machine by Realisations Ultrasonique, 9, Chaussée de Paris, Meaux (Seine-et-Marne). This completely automatic plant is equipped with cleaning, drying, washing and protection facilities.

Philips Industrie, 105, rue de Paris, Bobigny (Seine), exhibited a direct-reading industrial *p*H meter for dry cell operation. This model, the PR9401 is self-contained and portable. It is equipped with sub-miniature valves and temperature compensated over the range 0 deg. to 100 deg. Cent., also for asymmetric potential −150mV to +150mV and zero creep. Stability twenty minutes after switching on is claimed to be 0·02 *p*H per hour, input resistance is 5×10^{11} ohm. The case is 22·2cm by 14·2cm by 10·2cm.

On the Philips stand there was also be seen the "Thermocoax" thermo-electric micro-conductor. This is made in two versions, one of which comprises a sheath of metal chosen for its thermo-electric properties (generally copper or iron) in which is embedded a central conductor (generally of "Constantan"), with a refractory insulation in between. The junction is formed by removing some of the refractory near the end of the conductor and welding the core to the sheath. In the second kind, the sheath is there merely for protection and is made from 18/8 steel or "Inconel." Embedded in refractory insulation are two conductor wires made of two thermo-electrically different materials, e.g. "Chromel" and "Alumel," which are joined to form the thermo-couple junction. This cable is stated to have only a low thermal inertia on account of its outside diameter of between 0·5mm and 1mm, absolute tightness to vacuum or pressure, and high mechanical strength, complete electric self-shielding, high-quality insulation, capable of operation at up to about 900 deg. Cent., small capture section for neutrons, and complete temperature compensation of the leads. The ohmic resistance is high (24 and 37 ohms/m respectively), rendering it necessary to use this kind of wire in conjunction with electronic potentiometers, such as the Philips PR2210A or PR3200A.

House Construction in 1957

Comparison of the number of dwellings built in 1957 and in 1956 shows that the expansion of dwelling construction which was general in the years 1955–56 has halted in many European countries, according to a report published by the Economic Commission for Europe.*

The largest number of dwellings were built in the Soviet Union and Western Germany—approximately ten per 1000 inhabitants. These countries are immediately followed by the Netherlands, Norway and Sweden, with a production of eight to nine dwellings per 1000 inhabitants, and then Denmark, Finland, France, the United Kingdom and Switzerland, with six to seven, whereas Belgium, Hungary, Italy, Poland and Czechoslovakia built four to five per 1000 inhabitants. Eastern Germany, Ireland, Portugal, Spain and Yugoslavia had the least building, though, except for Ireland, their housing needs are very great.

Housing construction has nevertheless continued to increase in certain western European countries, such as Denmark, France, Italy, the Netherlands and Sweden, and in most of the countries of eastern Europe. The statistics indicate a levelling-off in the other western European countries, such as Belgium, Finland, Ireland, Norway, Portugal and the United Kingdom, or even a fairly pronounced drop, in Spain, Switzerland, and Western Germany.

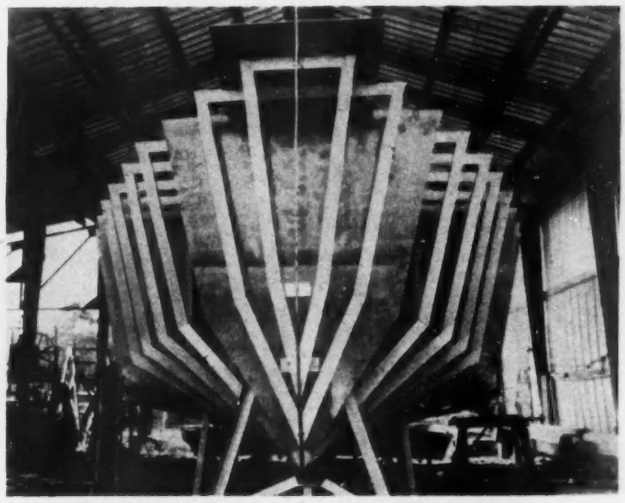
Some idea of the prospects for this year can be gleaned from the figures supplied for building permits and work in progress, which suggest that there is still some expansion in Italy, Norway and Sweden, whereas the tendency is definitely downward in most western European countries—particularly Western Germany, where there has been intensive construction in recent years. All the countries of eastern Europe expect some increase in dwelling construction. A more accurate gauge for measuring building activity in general, from the figures for apparent consumption, shows an increase in 1957 in most countries. This is considerable in eastern Europe, whereas there is a marked drop in Finland, the United Kingdom, and Western Germany. For the first time, the Bulletin gives information on the apparent consumption of cement. Building costs have increased slightly in most countries except in France, the United Kingdom and Western Germany, where they have gone up considerably, and in Portugal, where they have decreased.

International Conference on Quality Control

The European Organisation for Quality Control is holding a three-day conference at Essen from September 10 to 12 on the subject of "Consumer-Vendor Relations." Papers to be presented at the Conference will deal with the general, engineering, statistical, practical and theoretical aspects involved in the subject.

Application forms and further particulars about the conference can be obtained from British Productivity Council, 21, Tothill Street, London, S.W.1.

* "Quarterly Bulletin of Housing and Building Statistics for Europe," Vol. V, No. 4, fourth quarter, 1957. Can be obtained from Sales Section, European Office of the United Nations, Geneva, or may be ordered through Sales Agent for United Nations Publications, H.M. Stationery Office, P.O.B. 569, London, S.E.1. Price 4s. 6d.



(Left) Tugboat M.V. "Sumter," constructed entirely of aluminium alloys by Bryant Boats, Incorporated. (Right) Construction view of M.V. "Sumter," showing the aluminium alloy framing and No. 1 bulkhead

Aluminium Tugboat on Gulf Coast

BY OUR AMERICAN EDITOR

THE first aluminium tugboat to be built in the United States and the first aluminium vessel of any kind to be certified by the American Bureau of Shipping recently completed her trials after christening at New Orleans. Built by Bryant Boats, Incorporated, of Bayou LaBatre, Alabama, in co-operation with the Kaiser Aluminum and Chemical Corporation, the 55ft all-welded M.V. "Sumter" is designed for use in the bayous and marshland oilfields of Southern Louisiana. Its shallow 4ft 6in draught, made possible by its aluminium construction, will permit its use in waters too shallow for conventional tugs of this size.

Constructed of corrosion-resistant, high-strength weldable alloys 5083 and 5086, the aluminium vessel offers, in addition to its shallow draught, the advantages of long life relatively free of maintenance and economy of operation. Because of its aluminium construction, the boat is expected to experience less vibration and noise, reducing equipment wear and crew fatigue. The "Sumter" has facilities for a four-man crew. The main deck house has a galley, living quarters for two and a shower. Aft of the wheelhouse, on the second deck, are quarters for the master and mate, lockers and a lavatory. The fuel tanks are situated forward in the hull and the water tanks aft.

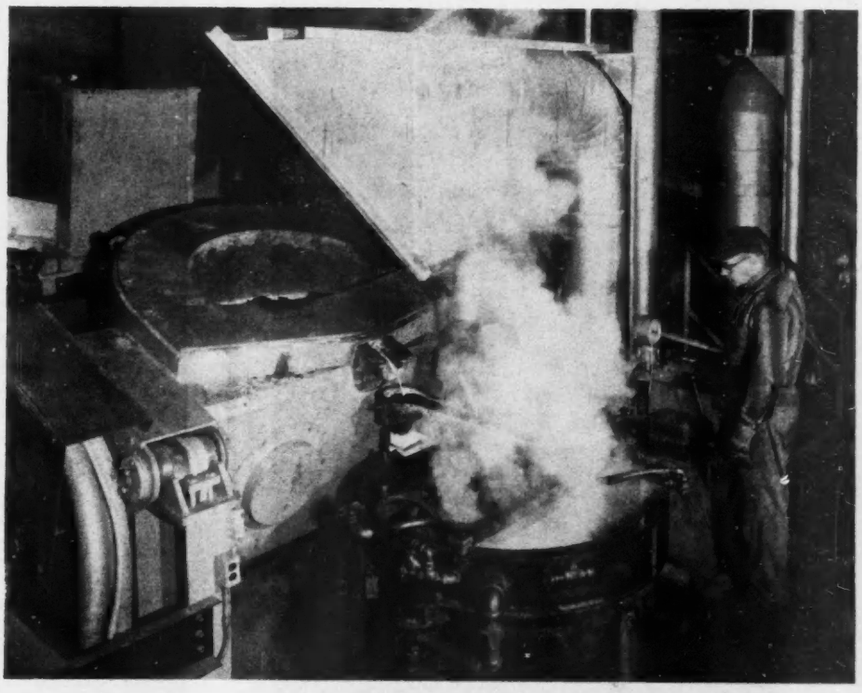
The requirements of the American Bureau of Shipping were that the tug should have strength and stiffness equal to that of steel, and these qualities were incorporated into the design. The hull has $\frac{1}{4}$in aluminium plate on the bottom and sides and $\frac{5}{16}$in plate on deck. The stern tube was fabricated from 5in extra heavy aluminium pipe. The tug is designed with six transverse watertight bulkheads and one centre-line watertight bulkhead. The only non-aluminium parts in the boat are those in the 440 h.p. diesel engines and the propeller and propeller shaft, which are made of bronze. Electrolytic action is prevented by separating dissimilar metals. The tailshaft of bronze is isolated from the aluminium hull by rubber bearings set in aluminium shells. The aluminium stuffing box was machined with adequate clearance, so that there is no contact with the bronze shaft. All bolts, set screws and other fastening devices are of stainless steel, with the main engines being installed on laminated plastic pads. The auxiliary generators, pumps and compressors have tape applied with adhesive to the underside of their bases. The aluminium piping is insulated from the pumps, engines and other equipment by means of rubber hose connections.

Except for anti-fouling paint on the bottom, no painting was required for anything but appearance, and a considerable cost saving was realised. According to the yard, a number of advantages were realised during construction. Because of light weight and ease of workability, hull construction required approximately 30 per cent less man-hours than a comparable boat made of steel. Aluminium proved an ideal material for a relatively small yard with limited equipment. Welders with no previous aluminium experience were able to pass A.B.S. certification with no difficulty, and welding was much more rapid than with steel. Cutting was accomplished by ordinary portable power saws, eliminating the necessity of using torches.

Continuous Casting Installation for Copper-Base Alloys

ONE of the more significant advances in copper and brass production technique has been achieved by the American Brass Company, who has just put into operation the industry's first casting equipment for both extrusion billets and rolling mill slabs based entirely on the semi-continuous casting process. This pioneering installation at the Ansonia Works in Connecticut is already producing metal of a quality greatly superior to that obtained previously by the conventional method of casting in individual moulds.

The new casting installation comprises a series of casting machines designed and built by Lobeck Casting Processes Incorporated, of New York City, each fed with liquid metal from "Ajax" electric induction furnaces. As shown in the accompanying illustration, the liquid metal flows from the furnace spout along a launder to a distributor which ensures a smooth, splash-free entry of metal into the moulds. The metal is cooled rapidly in passing through the water-jacketed "bottomless" moulds and is solid by the time it leaves them. The moulds are continuously filled with molten metal to match the withdrawal of the solidified castings until the ingots have been cast to their desired length. The machines at Ansonia are used to produce multiple-strand extrusion billets up to 8in



Continuous casting of 6in by 24½in "Everdur" copper-silicon alloy slab at the Ansonia works of the American Brass Company

CONTINUOUS-WELD PIPE MILL

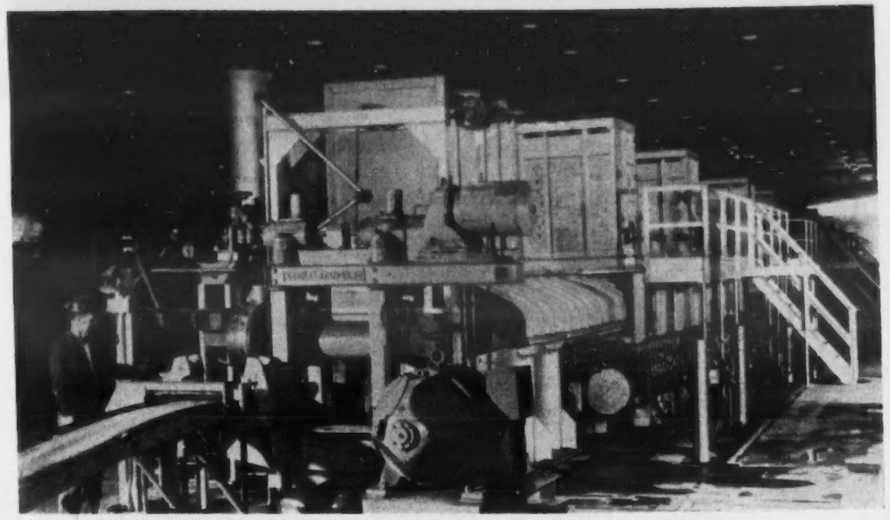


Fig. 1—Welding furnace at start of pipe mill through which skelp is passed continuously

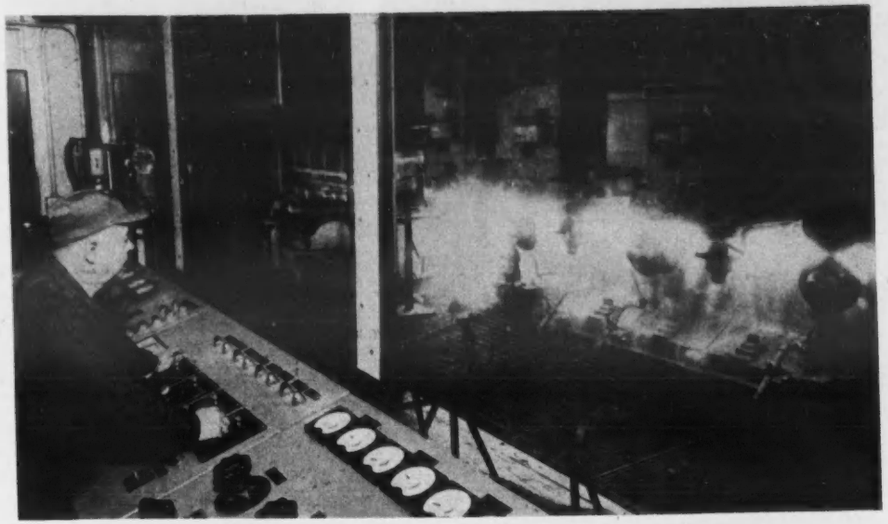


Fig. 2—Welding and forming stands of continuous pipe mill with control pulpit in foreground

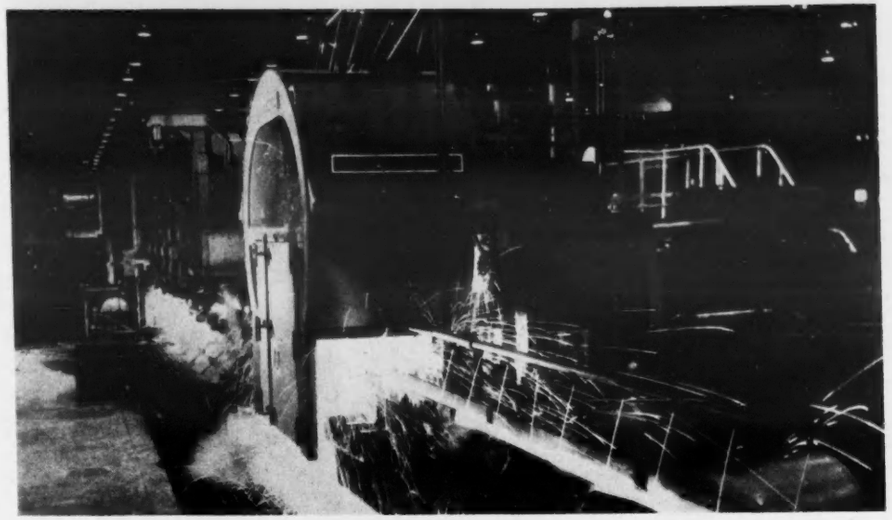


Fig. 3—Sizing end of mill with flying saw for cutting pipe into 42ft lengths

Fig. 4—Cooling rack at end of mill run-out table with adjacent water quenching tank

diameter and rolling mill slabs up to 6in by 24½in, in lengths up to 12ft. Each station has its own hydraulic power unit which allows the speed of casting and the length of stroke of the hydraulic ram to be carefully controlled. Only one operator is required per machine, with a helper assisting at the start of casting and at the final removal of the billets or slabs by overhead crane. In addition to such common copper-base alloys as gilding metal, commercial bronze, red brass, low brass, cartridge brass and yellow brass, the Lobeck installation has already produced special alloys such as leaded brasses, aluminium bronzes and "Everdur" copper-silicon alloys. The major benefits obtainable from the semi-continuous casting process include the following. 1. Mechanised operation and larger ingot sizes improve plant productivity. 2. Steady casting conditions give uniform, dense ingot structure from end to end. 3. Smooth metal pouring eliminates turbulence and entrapped oxides, dross and gases. 4. Rapid cooling produces a fine-grained, sound structure even in large cross-sections. 5. Predominantly longitudinal solidification prevents piping and internal stresses. 6. Longer casting length and small cropping losses improve yield. 7. Simple, short moulds reduce the cost of and space required by the casting shop inventory.

Continuous-Weld Pipe Mill

THE second of two modern continuous-weld pipe mills recently was put into operation by the Jones and Laughlin Steel Corporation to round out the current expansion programme at the Aliquippa Works, in Pennsylvania. The expansion programme at the Aliquippa Works, which has cost 200 million dollars over the past ten years, has increased steelmaking capacity at the plant and now gives the firm greatly expanded and modernised facilities for the production of seamless and welded pipe, tin plate, wire products and strip mill products and a broader range of structural shapes. The facilities added at the works include two basic oxygen furnaces, a 44in hot strip mill, an electric-weld line pipe mill, expanded soaking pit facilities and additions and improvements in many other departments. The two continuous-weld pipe mills replace two butt weld mills, which were built in 1926. The new mills are situated on the sites of these older mills in the Welded Tube Department.

The continuous-weld mill just put into operation is capable of producing welded pipe in a nominal size range of 1¼in to 4in. The first mill, completed in 1957, has a range of ½in to 2in nominal pipe size. The mills were built by the Aetna-Standard Engineering Company of Pittsburgh and installed by Patterson-Emerson-Comstock, Incorporated, of Pittsburgh.

In the operation of the continuous-weld pipe mill, coiled skelp is placed on an unreeling spool and one end is fed into a roller leveller. As the tail end of one coil is reached, the starting end of another coil is run through the flash welding machine and the two coils joined together to make one continuous ribbon of skelp. After the weld is made, the skelp passes through a trimming machine where the excess metal from welding is removed. The skelp is then paid out by means of pinch rolls to fill up a loop table. This loop table permits the welding of succeeding coils without a delay on the production line.

The skelp leaves the loop table and enters a 90ft long preheat furnace, makes a complete loop in this furnace, then comes out and makes another complete loop prior to entering the welding furnace. The welding furnace is 155ft long and 33in wide. It is fired by small gas burners arranged along each side at intervals of 9in to 10in. The skelp is brought to a welding temperature of 2450 deg. Fah. in approximately thirty seconds in this furnace. However, the centre of the skelp is kept several hundred degrees cooler than the edges to provide maximum pressure going through the welding roll.

As the skelp emerges from the furnace, jets of air are played on the edges to remove scale. The pipe rides through the furnace on raised skids and is not subject to silica scale which adheres to conventional welded pipe whose skelp lies on the furnace hearth. It then enters the forming and welding mill which consists of fourteen stands on the smaller mill. The first stand forms the skelp in a downward curve approximating a circle about 270 deg. closed. This formed skelp then passes through a "welding horn" which keeps it in position as it enters the second stand of rolls or welding pass. Before the skelp is forced through the welding pass, jets of air are blown on the edges to increase their temperature facilitating stronger welds. The edges are squeezed together in the pass thus forming a weld. After forming a weld, the pipe passes through the remaining stands where it is reduced in size without a change in the wall thickness.

The pipe then is forced through a sizing mill, where uniform outside diameter is obtained, and then cut to a 42ft length. It then advances to a splitting saw where the 42ft length may be cut into single lengths of 21ft, the standard American butt weld pipe length. It is then carried on a screw-type cooling bed which feeds it into a water bosh for cooling. Following the bosh, the pipe goes to one of two straighteners. When the pipe has been faced, it is subjected to its initial visual inspection on one of two inspection tables. One table is used for conduit and the other for other types of pipe.

As the pipe is inspected and accepted, it is hydrostatically tested in a new tube testing machine made by Schloemann A G. of Düsseldorf. This tester simultaneously tests five tubes with water pressure up to 3000 lb per square inch. The pipe is then transferred for either direct despatch or additional processing such as galvanising, threading or coupling.

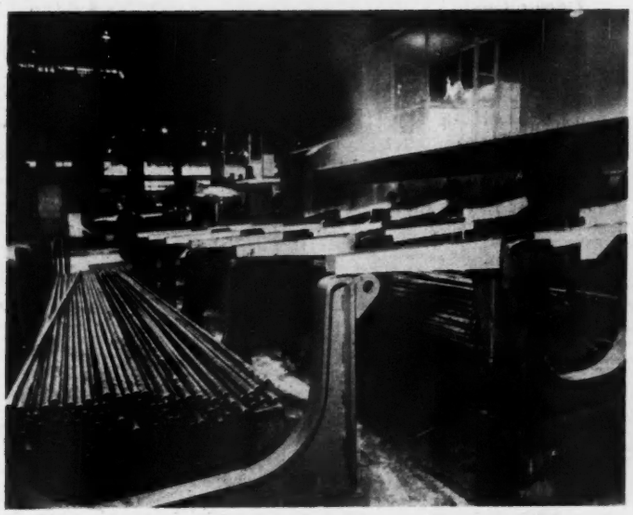
Material handling is completely automatic in the mills. From the time the skelp enters the welding furnace until it reaches the hydrostatic testers in the form of pipe, all transfers of the material during processing are carried out automatically. Skelp for the new mills is being produced on the firm's new 44in hot strip mill at the Aliquippa Works. The strip mill now processes larger diameter coils weighing as much as 18,000 lb each.

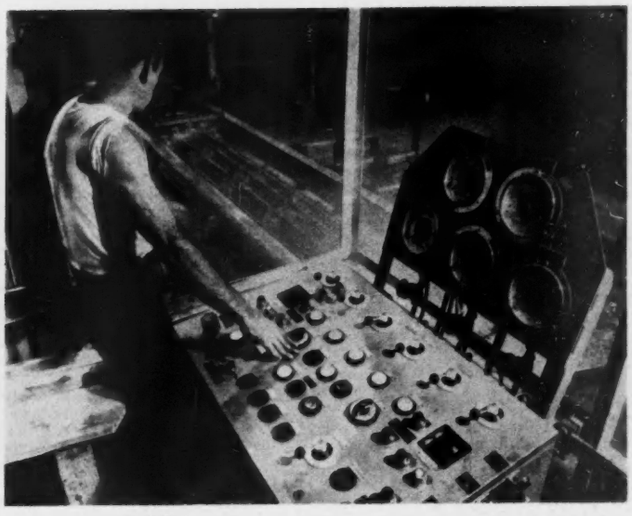
Reactor with Plutonium Fuel

A REACTOR of the U.S. Atomic Energy Commission is now operating for the first time at substantial power with plutonium–239 as the fuel. The Materials Testing Reactor (MTR) at the Commission's National Reactor Testing Station in Idaho, normally fuelled with uranium–235, was brought to criticality with plutonium as fuel on August 9 and is now operating at a power level of 5000 thermal kilowatts. The reactor is undergoing tests before operating later at a power level comparable with its design power level of 30,000 thermal kilowatts. This experiment with a plutonium fuel loading is expected to advance the technology of plutonium fuel-element handling and fabrication, provide operational experience with a plutonium-fuelled reactor, and provide reactor physics data.

The MTR, which began operating in 1952, provides facilities for determining the effect of intense reactor radiations on materials considered for use in fuel elements, heat transfer systems, structures and shields of new reactors. It is also used to test new and improved reactor fuel cores. Only minor design changes were required for the use of plutonium rather than uranium–235 as the fuel. Less plutonium than uranium–235 is required for an MTR fuel loading, because of the differences in their nuclear properties.

As an additional experiment with fuel loadings of different fissionable materials, the MTR, after a test period of power operation with the plutonium loading, will be loaded with fuel elements fabricated with uranium–233, the synthetic isotope of uranium derived from thorium. In a previous experiment, the MTR was operated successfully with a core loading of fuel elements containing uranium enriched to 20 per cent in U–235 rather than the usual high enrichment of 93 per cent. The plutonium fuel elements were fabricated at the Hanford Works, which is operated for the Commission by the General Electric Company. The MTR is operated for the Commission by the Phillips Petroleum Company.





Figs. 5 and 6—(Left) Schloemann hydrostatic tube testing machine for simultaneous testing of five tubes at pressures up to 3000 lb per square inch. (Right) Control station of Schloemann five-tube hydrostatic tube testing machine

Personal and Business

Appointments

MR. JAMES ROYCE has been appointed a director of Hedin, Ltd.

SUMMERSON'S FOUNDRIES, Ltd., announces that Mr. C. Whitehouse has been appointed works manager.

MR. T. W. FARRER, F.R.I.C., has joined Spencer and Partners, Consulting Engineers, 19, Grosvenor Place, London, S.W.1.

JAMES HODGKINSON (SALFORD), Ltd., announces that Mr. R. Yeoman has been appointed general manager for the group's foundries.

COMMANDER H. PASLEY-TYLER, R.N. (Retd.), has been appointed a director of Elliott Brothers (London), Ltd. He is at present joint general manager of the company.

SHEEPBRIDGE EQUIPMENT, Ltd., announces that Mr. J. S. Wood has been appointed a representative in its sand foundry division. He will be responsible for the Midland area.

LONDEX, Ltd., has appointed Mr. D. R. Western, 115, Overcliffe Drive, Southbourne, Bournemouth, as its technical representative for the area of Dorset, Hampshire and West Sussex.

ASSOCIATED COMMERCIAL VEHICLES, Ltd., announces that Mr. W. E. Dodsworth has been appointed a director of Park Royal Vehicles, Ltd., and Mr. R. O Boshell has been appointed a director of Charles Roe, Ltd.

ARMSTRONG SIDDELEY MOTORS, Ltd., has announced the appointment of Mr. J. M. Smith, A.M.I.Mech.E., M.I.Mar.E., as chief designer responsible for design and installation work relative to the Maybach engines.

CAPTAIN R. L. JORDAN, who was recently appointed a director of Fawcett Preston and Co., Ltd., has now joined the boards of Brookhirst Switchgear, Ltd., and Farmer Brothers (Shifnal), Ltd. All three companies are in the Metal Industries Group.

MR. BRUCE M. ADKINS, publicity manager of Elliott-Automation, Ltd., has been appointed public relations and information officer to the European Nuclear Energy Agency, a department of the Organisation for European Economic Co-operation, in Paris.

M. AND W. GRAZEBROOK, Ltd., has announced the retirement of Mr. A. C. Brooks after twenty-five years' association with the company. He will remain a director and will be available as consultant. Mr. J. Trevor-Jones has been appointed director in charge of sales.

YARROW AND CO., Ltd., announces that Sir Harold Yarrow has expressed his desire to relinquish his position as managing director of the company. He will remain as chairman. Mr. Eric Yarrow has been appointed to be managing director from October 1.

MR. A. KENNAWAY, A.M.I.Mech.E., has resigned from his position as head of the experimental engineering section of the plastics division of Imperial Chemical Industries, Ltd., to become assistant on plastics to the chief technical engineer of the Metal Box Company, Ltd.

MR. G. F. REYNOLDS, principal scientific officer, chemical inspectorate, Ministry of Supply, has been appointed chairman of the technical advisory panel of the British Polarographic Research Institute. Mr. W. J. Parker, secretary of the Institute, has resigned his appointment with Mervyn Instruments in order to devote more time to the development of the Institute. He will continue to act as polarographic consultant to the company.

GEORGE KENT, Ltd., has announced that Mr T. P. W. Norris has been appointed a director and deputy chairman. With effect from October 1, Mr. R. E. Handford, deputy managing director, is to relinquish his executive functions, but will retain his seat on the board of directors. Mr. W. A. Hartop has been appointed managing director, and Commander P. W. Kent, formerly chairman and managing director, remains as chairman. Mr. W. Guy Ardley, Hon.M.Inst.W.E., and Mr. Leslie H. Kent, A.M.I.C.E., M.I.Mech.E., directors, are to retire on September 30.

Business Announcements

PRESSED STEEL COMPANY, Ltd., has acquired new offices and showrooms in the Galerie Ravenstein in Brussels.

THE HOFFMANN MANUFACTURING COMPANY, Ltd., states that its Glasgow office and stockroom has been moved to 75, Robertson Street, Glasgow, C.2 (telephone, Central 0468/9).

FLEXIBOX, Ltd., Nash Road, Trafford Park, Manchester, 17, has appointed John Turner and Co., 25, Collingwood Street, Newcastle upon Tyne, 1, as its agent for the north-eastern area of Great Britain.

DR. RICHARD WECK, the director of the British Welding Research Association, has accepted an invitation from the American Society of Metals to lecture to its Seminar on residual stresses on October 30 and 31, and November 1, 1958, at Cleveland, Ohio.

SIMMONDS AEROCESSORIES PTY., Ltd., an Australian subsidiary of Simmonds Aerocessories, Ltd., Treforest, Glamorgan, has announced plans for a new factory and administrative building to be built on a site near its present factory in the Guncotton area of Ballarat, Victoria.

THE PLESSEY COMPANY, Ltd., announces that it has concluded a licensing agreement with General Instruments Corporation, New Jersey, covering the manufacture in Britain of silicon rectifiers for military, commercial and industrial uses, including missile systems, computers and television sets.

W. H. DORMAN AND CO., Ltd., states that its chairman and joint managing director, Mr. Darby Haddon, and its joint managing director and general manager, Mr. J. W. Whimpenny, have left London by air for an extended overseas tour which will include Canada, Australia, New Zealand and South and East Africa.

Contracts

WHESSOE, Ltd., has been awarded the contract for the supply and construction of the pressure vessel for the U.K. Atomic Energy Authority's advanced gas-cooled graphite-moderated reactor. The vessel is to be a vertical cylinder about 21ft in diameter with hemispherical ends. The overall height is to be 53½ft.

FERRANTI, Ltd., Hollinwood, Lancs, has received an order for a 4000kVA, 600kV a.c. testing equipment to be supplied to a cable manufacturer in Finland for cable testing. This equipment will incorporate power factor improvement by means of continuously variable moving coil reactors, and will be designed to operate either as a series or parallel resonant circuit.

THE AUTOMAITC TELEPHONE AND ELECTRIC COMPANY, Ltd., has received an order from the British Post Office for a wideband coaxial telephone system between Cardiff and Bristol. The new system, which makes better use of existing telephone cables, has unattended repeater stations every 3 miles and can carry up to 2700 telephone circuits, or, alternatively, 900 telephone circuits and one high definition television system, on one pair of coaxial tubes operating up to a frequency of 12·5 Mc/s. With this system the capacity of an existing cable will be almost trebled, since the present coaxial cable system with repeaters every 6 miles will only accommodate 960 telephone channels. The laying of a further cable under the Severn will be avoided.

Miscellanea

GRINDING MACHINE DEMONSTRATION.—A demonstration of some of the range of production and toolroom grinding machines made by Charles Churchill and Co., Ltd., Coventry Road, South Yardley, Birmingham, is to be held in the firm's showrooms from Monday, September 29 to Friday, October 3.

POLYTHENE LETTERS FOR MOULD PATTERNS.—Letters made of polythene for use in moulding patterns are now available from Aldridge Plastics, Ltd., 155, Charing Cross Road, London, W.C.2. These letters are pliable and can be moulded to any normal contour with ease : they can be glued or pinned to a pattern without difficulty and are unaffected by water. The makers point out the resilience of polythene letters enables them to withstand the most rigorous hand or machine ramming without fear of burrs forming and the resultant wastage of time caused by damage to moulds on pattern withdrawal. The inherent self-lubricating property of polythene overcomes any tendency letters have to stick in moulds.

CONFERENCE OF COMMONWEALTH SCIENTISTS.—The Conference of Commonwealth Scientists opened at Harwell on September 15, when representatives of nine Commonwealth countries were welcomed by Sir Edwin Plowden, chairman of the United Kingdom Atomic Energy Authority ; Sir John Cockcroft, member of the Authority for research ; Mr. W. Strath, member for external relations and commercial policy, and Mr. J. C. C. Stewart, deputy managing director of the Industrial Group, who was representing Sir William Cook, member of the Authority for engineering and production. There was an opening address by Sir Edwin Plowden, who said that since the early days of military work at Chalk River they had been accustomed to work together and, in addition to organised co-operation, there was the work of individuals. Sir John Cockcroft outlined atomic energy research and development in the United Kingdom. Mr. Stewart read a paper by Sir William Cook on "Engineering and Production in the Atomic Energy Authority," and Dr. B. F. J. Schonland, director of the Atomic Energy Research Establishment, gave a review of its work.

NICKEL ALLOYS.—A new publication entitled "Wiggin Nickel Alloys versus Caustic Alkalis" issued by Henry Wiggin and Co., Ltd., Thames House, Millbank, London, S.W.1, describes the properties of the high-nickel alloys used in the construction of plant handling caustic soda. Extensive data, giving comparative corrosion rates from a large number of both laboratory and plant tests, form a useful guide in the selection of the most suitable grade of material. We are informed that copies of the book are available without charge to chemical engineers and designers.

THERMONUCLEAR PROJECT FOR WINFRITH HEATH.—The Atomic Energy Authority announces that it proposes to move from Harwell to Winfrith Heath, Dorset, the whole of the controlled thermonuclear project. The transfer will take place between 1961 and 1963. This change will permit the development of both fission and fusion work at Winfrith, and allow room for whatever expansion of the latter is necessary in the future. It will also provide a margin for new work as yet unseen to be developed at Harwell. It will be recalled that development of the Winfrith Heath site started in September, 1957, and that one of the first projects is the construction of a high-temperature, gas-cooled reactor.

VALVES FOR CORROSIVE LIQUIDS.—A range of valves, from ¼in to 2in bore, introduced by the Chemical Pipe and Vessel Company, Ltd., Godstone Road, Kenley, Surrey, for handling corrosive and hot liquids, is made of "Fluon." Apart from hot corrosive liquids the valves can also be used for strong sulphuric acid, strong nitric acid and hot ferric chloride. They will withstand temperatures up to 200 deg. Cent., and are stated to be immune to corrosion by any known chemical. The valves are available with flanged ends, and in some cases screwed ends for low-pressure lines. The designs made include fine adjustment valves, pressure relief valves, on-and-off valves, and non-return valves.

PLASTICS IN THE TROPICS.—The Ministry of Supply has issued the eighth report of a series dealing with plastics in the tropics: it is concerned with asbestos filled phenolic resin. For the tests, specimens from five batches of asbestos filled phenolic resin sheet and mouldings were exposed to jungle undergrowth conditions in Nigeria for two years. It is stated that throughout the trial, little deterioration of the material occurred and the mechanical properties showed little change. An appreciable loss of strength took place in the electrical grade material but there was little change in its insulation resistance. The impact resistance of the materials increased slightly and the surfaces of all the specimens failed and became matt. The report is available from H.M. Stationery Office at 4s.

IMPACT NOISE ANALYSER.—A practical method of measuring impact noise in the workshop is now offered by the introduction of the type 1412 Impact Noise Analyser by Dawe Instruments, Ltd., 99, Uxbridge Road, London, W.5. This instrument, complete with self-contained batteries, weighs only 8½ lb. It employs three rectifier circuits feeding low-leakage capacitors, which store up electrical charges representative of different parameters of the noise until these charges can be displayed for a sufficiently long period to enable a reading to be taken. The first, or "peak" circuit, has an extremely short response time so that the magnitude of the most transient noise encountered in industry can be accurately determined by measuring the charge on the capacitor. The duration of the impact is established by noting the amount by which the charge of the "time-average" circuit—which has a relatively slow and adjustable response time—falls below that of the "peak" circuit. The third, or "quasi-peak" circuit, combines a fast response time with a decay time of about 0·6 second, which enables it to measure the magnitude of impact noises repeated too rapidly for readings to be taken with the "peak" circuit between successive impacts. Such intermittent noises as those emitted by pile drivers, drop stamps and the explosive hammers used for driving studs into concrete are measured with the "peak" circuit, while the "quasi-peak" circuit is used for rapidly repetitive noises such as those made by punch presses or road drills. The latter circuit also provides a convenient way of calibrating the analyser with reference to a sine wave input.

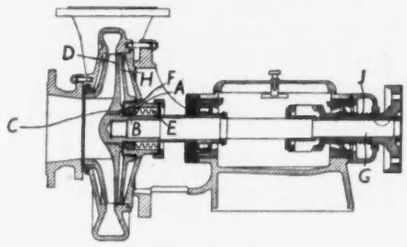
British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. 6d. each.

PUMPS

800,549. June 5, 1956.—CENTRIFUGAL PUMPS, Paul Bungartz, Leostrasse, 87, Düsseldorf-Oberkassel, Germany.

The invention relates to centrifugal pumps having an auxiliary feed wheel to keep the clearance on the shaft sealed when operating the pump and has as its object in particular the further development and improvement of pumps in which the sealing of the shaft passage opening a seal is opened by an axial movement of the shaft on operating the pump and



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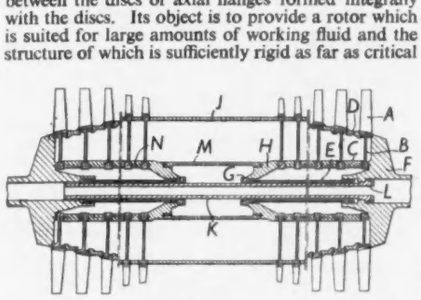
is closed when same is stopped. As shown in the drawing a seal *A* has a sealing surface *B* facing a corresponding surface *C* on the rotor *D* and is located on a spring member *E* which has the form of a spring bellows. When the seal is released, as is the case when the pump is working, the seal *A* engages a shoulder *F* of the passage in the casing for a shaft *G*. In this case the leaking liquid flowing along the shaft is thrown off by an auxiliary feed wheel *H* so that there is still a sealing via the shoulder *F* engaging the seal *A*. If on stopping the pump the rotor *D* is drawn back into the neutral position by a spring *J* then the sealing surface *B* again contacts the surface *C* on the rotor *D*, before the auxiliary feed wheel *H* ceases to act. The spring body *E* has a smaller tension than that of the spring *J*. A modified design is also shown in the specification.—*August* 27, 1958.

AIR COMPRESSORS

800,524. October 8, 1956.—ROTARY COMPRESSORS OF THE AXIAL FLOW TYPE, Svenska Turbinfabriks Aktiebolaget Ljungström, Finspong, Sweden.

The invention relates to axial flow compressors having a double-sided inlet for the fluid and a rotor comprising axially spaced blade supporting discs and distance elements positioned at different radii therebetween and consisting either of rings between the discs or axial flanges formed integrally with the discs. Its object is to provide a rotor which is suited for large amounts of working fluid and the structure of which is sufficiently rigid as far as critical



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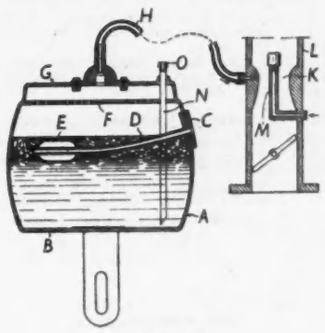
speed and large torques are concerned and permits a simple mounting. As will be seen in the drawing, the rotary blades *A* and *B* are discs supporting the blades. Inserted between the hubs of the discs are distance rings *C* and inserted between the rings of the discs are distance rings *D*. The discs and the associated distance rings of each unit are clamped together axially by a hollow bolt *E* threaded at one end into the respective journal *F* of the compressor and provided at its other end with a flange *G* engaging a ring *H* bearing against the hub of the innermost disc of the unit. Inserted between the units at the periphery is a distance sleeve *J* engaging by its ends the rims of the innermost discs of the two units. Extending through the hollow bolts *E* is a tension bolt *K* threaded by its one end into the one journal *F* and engaging the other journal by means of a flange *L*. The rotor is adapted to be rotated from one end, thus, the distance sleeve *J* has to transmit the torque between the units. Should the distance sleeve not be capable of doing this, there may be provided, as shown, a separate torque transmitting member between the units. In the drawing the member comprises a sleeve *M* located inside the distance sleeve *J*, which is inserted with an axial play between the rings *H* of the units while engaging the rings so as to positively hold them against rotation with relation to each other. For transmitting the torque between the discs *B* of each unit pins *N* are inserted through the hub portions of the discs *B* and the distance rings *C*. These pins may each extend through the entire respective unit or only through a portion thereof. Though not shown in the drawing, non-rotary guide blade rings supported by a stationary compressor housing may be provided between the rotary discs. The fluid, as air, to be compressed is entered at the ends of the compressor and discharged in the middle.—*August* 27, 1958.

INTERNAL COMBUSTION ENGINES

800,508. June 6, 1956.—DEVICES FOR HUMIDIFYING THE INTAKE AIR OF COMBUSTION ENGINES, Societé Hygrotechnique, 5, Quai de Grenelle, Paris, France.

The invention relates to devices for introducing a predetermined concentration of water vapour into the intake air of an internal combustion engine. As shown in the drawing, *A* is the humidifier unit of the invention, comprising a water container or tank *B*. In an aperture in a side wall of the tank a flexible insert *C* is sealed and a pipe *D* has one end projecting into the tank, a float *E* being supported on the inner end of the pipe. The top wall of the tank *B* comprises a perforated plate *F* with a collector space *G* above. Connected with the top of collector *G* is a conduit *H*, which is connected with the venturi throat section *K* of a conventional carburettor *L*. A carburettor jet is illustrated at *M*. A vertical dipper pipe *N* extends to a point near the bottom of tank *B*. The general operation of the system is as follows. Air enters the



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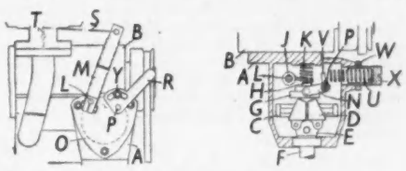
tank *B* through the pipe *D*. Due to the action of the float *E*, the depth of water overlying the outlet of pipe *D* remains substantially constant regardless of the particular level of the water filling the tank. Thus the air entering the tank and issuing from the inner outlet of pipe *D*, as indicated by the bubbles, will always traverse the same depth of water and will absorb a constant amount of moisture. The moisture-laden air flows through the perforations in wall *F*, which serves to arrest any entrained droplets of liquid water, and flows through pipe *H* into the venturi of carburettor *L*, so as to provide a mix of optimum composition. The moisture content in the mix is thus automatically regulated in an accurate manner even at very low rates of fuel feed to the engine, and a highly flexible operation of the engine with low fuel consumption is obtained. For a higher range of fuel feed, however, the flow section of pipe *D* may be insufficient relatively to the amount of humidity absorbed, so that the make-up air tube *N* is provided, which has a calibrated inlet orifice *O* at its top end. Two modified float systems are also shown in the specification.—*August* 27, 1958.

800,315. October 4, 1956. — CENTRIFUGAL GOVERNORS, Ferdinand Porsche, personally responsible partner of the firm of Dr.-Ing. h.c.F. Porsche K.G., Moritz-Horkheimer Strasse 25, Stuttgart-Zuffenhausen, Germany.

The invention relates to a centrifugal governor for internal combustion engines, especially stationary engines, which comprises an adjusting spring for adjusting the centrifugal governor to any desired control responsiveness as regards the speed of rotation. Referring to the drawing, *A* is the housing which carries the generator *B* driven by the engine. The centrifugal governor *C* within the housing consists of two fly weights *D*, mounted on a sleeve *E* secured to the driving shaft *F* and acting through a control sleeve *G* and a pin *H*. The control pin *H* is surrounded by the control sleeve and abuts at its free end against a control member *J*. This member, which is under the influence of the return spring *K*, is operatively connected with a shaft *L* which transmits the control movement to an adjusting rod *M*. An adjusting fork *N* is connected by guide pins with the control sleeve *G*. The adjusting fork *N* is rotatably supported by means of a bushing in an eye of the cover *O* closing the housing. The bushing and the fork are provided with a bore in which is arranged a torsion-rod spring *P* which is secured in a readily detachable manner by a locking pin. The torsion rod is provided with an enlarged end which is operatively connected with an adjusting lever *R* and is rotatably guided in the bearing bore of the eye. In operation, if the shaft *F* rotates, the fly weights *D* are moved radially outwardly, whereby the control pin *H* is



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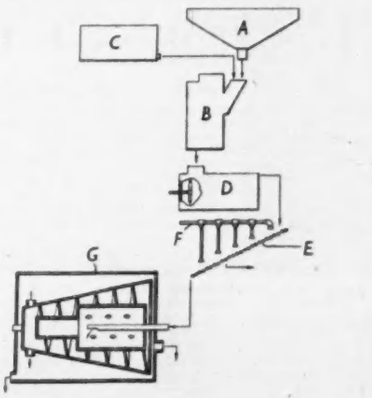
forced against the control member *J*. By the adjustment of the pin *H* and of the control member *J* the control rod *M* is adjusted correspondingly, which in turn adjusts over a rod linkage *S* the throttle valve *T* corresponding to the desired rotational speed of the engine. For the purpose of adjusting a desired preselected rotational speed to which the governor is responsive, the adjusting lever *R* is actuated whereby the torsion of the control spring constituted by the torsion-rod spring *P* influences over the fork *N* and the control sleeve *G* the effect of the fly weights *D* on the control member *J*, which in turn determines the position of the throttle valve. In order to adjust a larger rotational speed adjusting range as accurately as possible the additional spring *U* becomes effective over the abutment member *V* after a predetermined annular displacement of the torsion-rod spring *P*. The effect of the additional spring may be changed by loosening the nut *W* and the adjustment of the threaded bush *X*. For the purpose of adjusting a constant speed of rotation, as is required with generators, the position of the adjusting lever *R* may be fixed by the clamping bolt *Y*. While one preferred embodiment of the invention has been described, it is pointed out that the invention is not limited to it, thus the governor may be formed as an independent unit and arranged at any suitable place on the internal combustion engine.—*August* 27, 1958.

MINING ENGINEERING

800,487. December 17, 1956.—METHOD OF CLEANING FINE COAL, United States Steel Corporation, 525, William Penn Place, Pittsburgh, 30, Pennsylvania, U.S.A.

The invention relates to a method for cleaning fine coal, i.e. smaller than 100 mesh, by removal of the particles of refuse, such as clay, mixed therewith.



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In the preferred practice of the invention, as illustrated in the drawing, a water slurry containing about 20 per cent of coal fines under 100 mesh in size is delivered from a conventional coal-preparation plant to a thickener *A*. The underflow from the thickener, with solids concentration increased to about 50 per cent, is delivered to a phase-inversion mill *B*. Hydrocarbon oil such as kerosene is admitted to the mill from a tank *C* in an amount about 10 per cent of

the solids contained in the slurry. In mill *B*, the coal particles become intimately mixed with the oil and are effectively coated thereby. After thorough mixing in mill *B* the slurry of oiled particles of coal and the clay or refuse originally contained is discharged into a conditioner *D*. This is simply a tank provided with an agitator for effecting a slow stirring of the slurry. Such treatment causes the oiled coal particles to come in contact and cling together. From the conditioner, the mixture is discharged upon a flat, inclined vibrating screen *E* of from 50 to 70 mesh, preferably about 60 mesh. The water of the slurry runs through the screen but the oiled coal particles cling together and are held thereon and the mixture gradually descends the sloping surface. During this descent, additional wash water is discharged upon the mixture from sprays *F*. The water of the starting slurry and the additional wash water passing through the screen carry away the clay initially present, thus effecting an almost complete removal of refuse from the coal particles. The cleaned coal from the screen *E* is delivered into a centrifugal solid-bowl separator *G* which removes nearly all the water from the coal, leaving it as a relatively dry (6 to 8 per cent water) mass of palpable particles containing almost no clay or other refuse.—*August* 27, 1958.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ANTIQUARIAN HOROLOGICAL SOCIETY

Sat., Oct. 4.—Chartered Auctioneers' and Estate Agents' Institute, Regent House, St. Philip's Place, Colmore Row, Birmingham, 3, "Some Outstanding Continental Clocks of the Sixteenth and Early Seventeenth Centuries," H. von Bertele; "The Design of English Domestic Clocks," P. G. Dawson, and "The Performance of Early Watches in Everyday Use," C. Clutton, 2 p.m.

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

Wed., Oct. 1.—HALIFAX BRANCH: Crown Hotel, Horton Street, Halifax, "Radio Control," E. B. Hill, 7.45 p.m. ★MANCHESTER BRANCH: Engineers' Club, Albert Square, Manchester, 2, "Floor and Block Storage Heating," C. J. Wheeler, 7 p.m. ★NORTH LONDON BRANCH: Wood Green Hall, Wood Green, London, N.22, "Photo-Electric Cells and Industrial Applications," G. A. G. Ive, 7.45 p.m. ★PRESTON BRANCH: R.A.F.A. Club, East View, Preston, "Motor Control Gear," S. H. Harding, 7.30 p.m.

Thurs., Oct. 2.—GLASGOW BRANCH: Institution of Engineers and Shipbuilders in Scotland, 39, Elmbank Crescent, Glasgow, C.2, "Lighting in Moscow," A. G. Penny and J. F. Stanley. ★SOUTHAMPTON BRANCH: Pilgrim Room, Polygon Hotel, Southampton, "Theatre Electrical Engineering," 8 p.m.

Fri., Oct. 3.—BRISTOL AND WEST OF ENGLAND BRANCH: Royal York Hotel, Bath, "The Transatlantic Telephone Cable," 8 p.m. ★LIVERPOOL AND DISTRICT BRANCH: Industrial Development Centre, M.A.N.W.E.B., Paradise Street, Liverpool, 1, "Planned Maintenance," G. D. Rendel, 7.30 p.m. ★OXFORD AND DISTRICTS BRANCH: Malborough Club, Didcot, "The Electrical and Electronic Aspects of 'Zeta,'" L. Clarke, 7.30 p.m.

Sat., Oct. 4.—SOUTH EAST LONDON BRANCH: Visit to S.S. "Oronsay," Tilbury Docks, 3 p.m.

BRITISH INSTITUTE OF MANAGEMENT

Fri., Oct. 3.—Assembly Hall, Royal Commonwealth Society, Craven Street, Charing Cross, London, W.C.2, Fourth Elbourne Memorial Lecture, "The Great Tomorrow," The Earl of Verulam, J.P., 8 p.m.

BRITISH INSTITUTION OF RADIO ENGINEERS

Thurs., Oct. 2.—SOUTH WESTERN SECTION: School of Management Studies, Unity Street, Bristol, 1, Inaugural Meeting; Address by Rear-Admiral Sir Philip Clarke; "The Scope and Applications of the Modern Digital Computer," A. D. Booth, 7 p.m. ★NORTH WESTERN SECTION: Reynolds Hall, College of Technology, Sackville Street, Manchester, 1, "Television Studio Techniques," J. Chen, 6.30 p.m.

Fri., Oct. 3.—SOUTH MIDLANDS SECTION: North Gloucestershire Technical College, Cheltenham, "Nuclear Instrumentation," J. Thomas, 7 p.m.

ILLUMINATING ENGINEERING SOCIETY

To-day, Sept. 26.—BIRMINGHAM CENTRE: Regent House, St. Philip's Place, Colmore Row, Birmingham, Chairman's Address, "Modern Lighting and Production," L. E. Gibbs, 6 p.m.

Mon., Sept. 29.—LEICESTER CENTRE: Demonstration Theatre, East Midlands Electricity Board, Charles Street, Leicester, Chairman's Induction, 7 p.m.

Wed., Oct. 1.—EDINBURGH CENTRE: Y.M.C.A., 14, South St. Andrew Street, Edinburgh, "Lighting in Moscow," A. G. Penny, 6.30 p.m. ★NEWCASTLE UPON TYNE CENTRE: Lecture Theatre, Grey Hall, Department of Electrical Engineering, King's College, College Road, Newcastle upon Tyne, 1, Chairman's Address, H. Ainsworth, 6.15 p.m. ★SWANSEA GROUP: Demonstration Theatre, South Wales Electricity Board, The Kingsway, Swansea, Chairman's Address, G. W. E. Timms, 6.30 p.m.

Thurs., Oct. 2.—CARDIFF CENTRE: Demonstration Theatre, South Wales Electricity Board, The Hayes, Cardiff, Chairman's Address, F. H. Pulvermacher, 6 p.m. ★MANCHESTER CENTRE: Regional College of Art, All Saints, Manchester, 15, "Lighting in Interior Decoration," Sir Gordon Russell, 7 p.m.

Mon., Oct. 6.—LEEDS CENTRE: Yorkshire Electricity Board, Ferensway, Hull, "Lighting for Sport," M. W. Pierce, 6.30 p.m.

INCORPORATED PLANT ENGINEERS

To-day, Sept. 26.—BIRMINGHAM BRANCH: Imperial Hotel, Temple Street, Birmingham, "Planned Maintenance," A. F. R. Stedman, 7.30 p.m.

Mon., Sept. 29.—WEST AND EAST YORKSHIRE BRANCH: Fuel Department Lecture Theatre, New Building, The University, Leeds, "Mechanical Plant and Railway Engineering," A. C. Layhe, 7.30 p.m.

Wed., Oct. 1.—LEICESTER BRANCH: Bell Hotel, Leicester, "What Management Expects of the Plant Engineer," W. J. Worsdell, 7 p.m.

Thurs., Oct. 2.—SOUTHERN BRANCH: Polygon Hotel, Southampton, Discussions: "Safety Precautions," opened by A. Simmonds and "Preventive Maintenance" opened by F. V. Woods, 7.30 p.m.

Tues., Oct. 7.—LONDON BRANCH: Royal Society of Arts, John Adam Street, Adelphi, Strand, London, W.C.2, "The Free Piston Engine and its Application," R. W. S. Mitchell, 7 p.m. ★EDINBURGH BRANCH: 25, Charlotte Square, Edinburgh, "District Heating," G. E. H. Lewis, 7 p.m. ★PETERBOROUGH BRANCH: White Lion Hotel, Church Street, Peterborough, "The Jodrell Bank Radio Telescope," 7.30 p.m.

INSTITUTE OF BRITISH FOUNDRYMEN

Tues., Sept. 30.—SLOUGH SECTION: Lecture Theatre, High Duty Alloys, Ltd., Slough, Brains Trust, "Precision-Casting Techniques," 7.30 p.m.

INSTITUTE OF MARINE ENGINEERS

Mon., Oct. 6.—Memorial Building, 76, Mark Lane, London, E.C.3, "The Junior Engineer's First Trip to Sea," H. C. Gibson, 6.30 p.m. ★MERSEYSIDE AND NORTH WESTERN SECTION: Liverpool Engineering Society, The Temple, Dale Street, Liverpool, "An Introduction to Fatigue in Marine Engineering," B. K. Batten, 6 p.m.

Tues., Oct. 7.—Memorial Building, 76, Mark Lane, London, E.C.3, Presidential Address, "The Training of Seagoing Engineers," E. L. Denny, 5.30 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Mon., Oct. 6.—SCOTTISH CENTRE: Institution of Engineers and Shipbuilders, Elmbank Crescent, Glasgow, "Oxy-Acetylene Welding Techniques," R. Sandey, 7.30 p.m.

Tues., Oct. 7.—WEST REGIONAL CENTRE: Liverpool Architectural Society's Rooms, Bluecoat Chambers, School Lane, Liverpool, 1, "The Free Piston Gasifyer with Special Reference to Vehicle Applications," F. J. Wallace, 7.30 p.m. ★WESTERN CENTRE: Royal Hotel, Bristol, "Road Transport Law," 6.30 p.m. ★EASTERN CENTRE: Swan Hotel, Bedford, "Trends in Modern Road Passenger Transport," R. Cox, 7 p.m.

INSTITUTION OF CIVIL ENGINEERS

Thurs., Oct. 2.—NORTH WESTERN ASSOCIATION: Engineers' Club, 17, Albert Square, Manchester, Chairman's Address, J. P. Bamber, 6.30 p.m.

Tues., Oct. 7.—Great George Street, Westminster, London, S.W.1, "Engineering Problems in Recent River Valley Projects in India," K. L. Rao, 5.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Tues., Sept. 30.—CAMBRIDGE RADIO AND TELECOMMUNICATION GROUP: Cavendish Laboratory, Free School Lane, Cambridge, Six Papers on "Applications of Electronics," 8 p.m.

Wed., Oct. 1.—SOUTHERN CENTRE: C.E.G.B. Offices, 111, High Street, Portsmouth, Chairman's Address, G. Bishop, 6.30 p.m.

Mon., Oct. 6.—EAST ANGLIAN SUB-CENTRE: Technical College, Cambridge, Chairman's Address, R. A. W. Connor, 6.30 p.m. ★MERSEY AND NORTH WALES CENTRE: Royal Institution, Colquitt Street, Liverpool, Chairman's Address, J. Collins, 6.30 p.m.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND

Tues., Oct. 7.—39, Elmbank Crescent, Glasgow, Presidential Address, J. Small, 6.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, Sept. 26.—NORTH-WESTERN BRANCH: BARROW-IN-FURNESS PANEL: Lecture Theatre, College for Further Education, Abbey Road, Barrow-in-Furness, "Application of Nuclear Power to Marine Propulsion," J. E. Richards, 7.30 p.m.

Sat., Sept. 27.—SCOTTISH BRANCH: Visit to Calder Hall Atomic Power Station. ★SOUTHERN BRANCH: Visit to the Esso Research Laboratories, near Abingdon, 10.15 a.m.

Mon., Sept. 29.—SOUTHERN GRADUATES' SECTION: Cockcroft Hall, Harwell, "Gas Lubricated Bearings and their Applications," D. Pantall, 3.30 p.m.

Thurs., Oct. 2.—NORTH WESTERN BRANCH: Engineers' Club, Albert Square, Manchester, Paper on "Zeta," 6.45 p.m. ★SCOTTISH BRANCH: Royal College of Science and Technology, Glasgow, "Application of Nuclear Power to Marine Propulsion," J. E. Richards, 7.30 p.m. EAST MIDLANDS GRADUATES' SECTION: College of Art, Green Lane, Derby, "Design and Development of Engines for High-Speed Flight," E. S. Moult, 7.15 p.m. ★SOUTHERN GRADUATES' SECTION: Technical College, Southampton, Film Show, 7.30 p.m.

Fri., Oct. 3.—YORKSHIRE GRADUATES' SECTION: Visit to the Aircraft Equipment Division, English Electric Company, Ltd., Bradford, 6 p.m. ★SCOTTISH BRANCH: Dick Institute, Kilmarnock, "Application of Nuclear Power to Marine Propulsion," J. E. Richards, 7.30 p.m.

Mon., Oct. 6.—NORTH EASTERN BRANCH: Neville Hall, Westgate Road, Newcastle upon Tyne, Chairman's Address, Sir William Scott, 6 p.m.

Tues., Oct. 7.—NORTH EASTERN BRANCH: Cleveland Scientific and Technical Institute, Corporation Road, Middlesbrough, "Packed Glands for High Pressures: An Analysis of Fundamentals," J. L. Thompson, 6.15 p.m. ★COVENTRY A.D. CENTRE: Grosvenor Room, Leofric Hotel, Coventry, "Fatigue Testing in Vehicle Components," T. C. Stott, 7.15 p.m. ★LONDON AUTOMOBILE DIVISION: 1, Birdcage Walk, Westminster, London, S.W.1, Annual Meeting, Chairman's Report for 1957–58; New Chairman's Address, 6 p.m. ★EASTERN BRANCH: College of Technology and Arts, Rugby Joint Meeting with the Rugby Panel of the East Midlands Branch: "The Design and Development of Lightweight Marine Gas Turbines for Electric Generator Drive," A. W. Pope, 6.30 p.m.

INSTITUTION OF NAVAL ARCHITECTS

Tues., Sept. 30.—SOUTHERN JOINT BRANCH: College of Technology, Portsmouth, Joint Meeting with the Institute of Marine Engineers, "Recent Developments in Ship Motion Research," E. C. Tupper, 7.30 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

Wed., Oct. 1.—NOTTINGHAM SECTION: Reform Club, Victoria Street, Nottingham, "Thermal Insulation of Factories," 7 p.m. ★DUNDEE SECTION: Windmill Hotel, Arbroath, Dundee, "Copy Turning—Its Developments and Technique," 7.30 p.m.

Sat., Oct. 4.—WOLVERHAMPTON GRADUATE SECTION: Morning Visit to Carpet Trades, Ltd., Kidderminster. ★NEWCASTLE UPON TYNE GRADUATE SECTION: Visit to Newcastle Breweries, Ltd., Haymarket, Newcastle upon Tyne, 10 a.m.

INSTITUTION OF STRUCTURAL ENGINEERS

Wed., Oct. 1.—NORTHERN COUNTIES BRANCH: Neville Hall, Newcastle upon Tyne, Address by D. W. Portus, 6.30 p.m.

Thurs., Oct. 2.—LONDON BRANCH: 11, Upper Belgrave Street, London, S.W.1, Presidential Address, G. S. McDonald, 6 p.m.

JUNIOR INSTITUTION OF ENGINEERS

Wed., Oct. 1.—MIDLAND SECTION: James Watt Memorial Institute, Great Charles Street, Birmingham, Annual General Meeting; Chairman's Address, "Railway Traction," H. M. Campbell, 6.30 p.m.

Fri., Oct. 3.—Pepys House, 14, Rochester Row, Westminster, London, S.W.1, Films; "The Practice and Application of Modern Air Survey Methods," R. G. Mott, 7 p.m.

PLASTICS INSTITUTE

Thurs., Oct. 2.—SOUTHERN SECTION: Chemistry Department, The University, Southampton, "The Processing Properties and Applications of Zeigler Polyethylenes," S. Squires, 7.30 p.m.

Fri., Oct. 3.—NORTH WESTERN SECTION: Textile Institute, Blackfriars Street, Manchester, "Polyester Resin Glass Fibre Moulding by the Matched Metal Moulding Method," H. R. Everard, 6.45 p.m.

ROYAL SOCIETY OF HEALTH

Thurs., Oct. 2.—COLCHESTER SESSIONAL MEETING: Town Hall, Colchester, "The Practical Integration of Health Services," J. D. Kershaw, and "New Houses for Old: An Experiment in the Modernisation of Ancient Houses," W. A. Rapier, 10 a.m.

SOCIETY OF CHEMICAL INDUSTRY

Wed., Oct. 1.—CORROSION GROUP: 14, Belgrave Square, London, S.W.1, "Corrosion Embrittlement; The Effect of Cathodically Evolved Hydrogen on Iron and Nickel," M. Smialowski, 6.30 p.m.

SOCIETY OF ENGINEERS

Mon., Oct. 6.—Geological Society, Burlington House, London, W.1, "The Bridge on the River Kwai," K. H. Best, 5.30 p.m.

SOCIETY OF INSTRUMENT TECHNOLOGY

Tues., Sept. 30.—LONDON SECTION: Manson House, Portland Place, London, W.1, "Frequency Response Analysis using Describing Function Method," J. C. West, 5.30 p.m.

Wed., Oct. 1.—SOUTH WALES SECTION: Physics Lecture Theatre, Welsh College of Advanced Technology, Cardiff, "Some Applications of Optics in Steel Making Problems," C. Burns, 6.45 p.m.

Thurs., Oct. 2.—GRANGEMOUTH SECTION: Leapark Hotel, Grangemouth, "Data Loggers," H. Williamson, 7 p.m.

Fri., Oct. 3.—FAWLEY SECTION: Copthorne House, Fawley, Hants, "The Evaluation of Instruments for Chemical Processes," D. M. Bishop.

Mon., Oct. 6.—SOUTH YORKSHIRE SECTION: The University, St. George's Square, Sheffield, 1, "The Education and Training of Instrument Personnel," E. B. Jones, 7 p.m.

Advanced Engineering Courses

Communication Engineering Economics. DEPARTMENT OF ELECTRICAL ENGINEERING, South East London Technical College, Lewisham Way, London, S.E.4. A course of twenty-six lectures, commencing Monday, October 6, 6.45 p.m., of particular interest to Post Office engineers and traffic officers and to staff of firms engaged in the preparation of tenders for the supply and installation of communication equipment for export. Application should be made to the Head of the Electrical Engineering Department. Fee £1 12s. 6d.

Electronic Computing Systems. Part I: The Construction and Operation of Electric Digital Computing Systems Designed for Commercial Purposes. DEPARTMENT OF MATHEMATICS, SIR JOHN CASS COLLEGE, Jewry Street, Aldgate, London, E.C.3.—A course of nine lectures, commencing Wednesday, October 8, 6.30 p.m., intended for executives and others interested in the commercial applications of electronic computers. Application should be made to the Secretary of the College. Fee, for those residing in the County of London, £1.

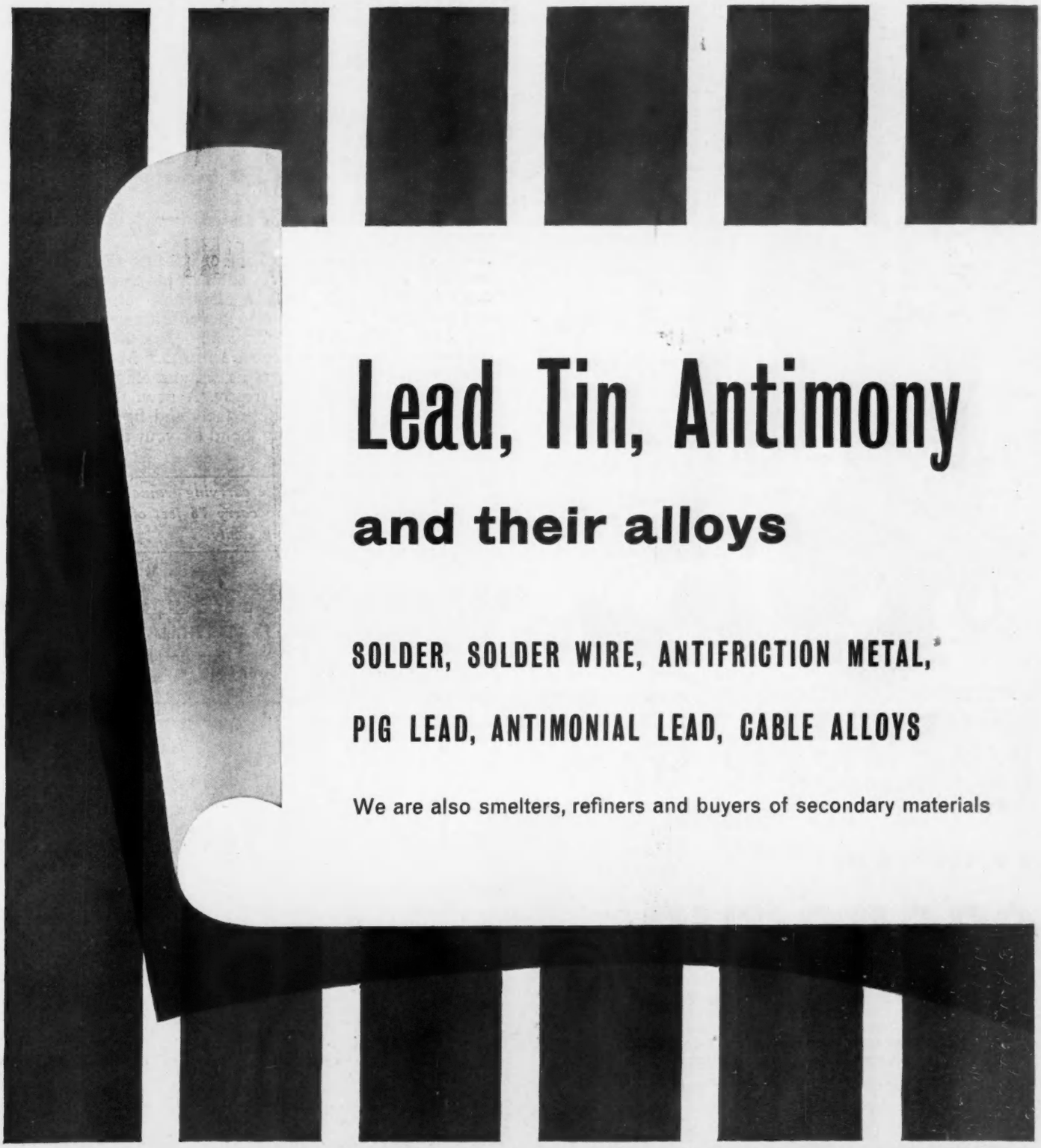
Refractories, Their Manufacture, Properties and Applications. BOROUGH POLYTECHNIC, Borough Road, London, S.E.1. A course of ten lectures, to be given by L. R. Barrett, commencing Friday, October 10, 7 p.m. The course is organised to provide a detailed and up-to-date survey of refractories and the refractories industry. Fee £1.

The Application of Work Study. UNIVERSITY INSTITUTE FOR ENGINEERING PRODUCTION, "Southfield," 16, Norfolk Road, Edgbaston, Birmingham, 15. Residential executive course from Monday, October 13, to Friday, October 24. Application should be made to Dr. N. A. Dudley, Director of the Institute for Engineering Production. Fee 50 guineas.

Spectrochemical Analysis. DEPARTMENT OF CHEMISTRY, SIR JOHN CASS COLLEGE, Jewry Street, Aldgate, London, E.C.3. A course of eleven lectures commencing Wednesday, October 1, 6 p.m. Application should be made to the Secretary. Fee, for those residing in the County of London, £1.

Statistical Mechanics. DEPARTMENT OF PHYSICS, SIR JOHN CASS COLLEGE, Jewry Street, Aldgate, London, E.C.3. An introductory course of ten lectures, commencing Thursday, October 2, 6 p.m., suitable for graduates in physics or chemistry and covering the essential principles of statistical machines and some important applications. Fee, for those residing in the County of London, £1.

Fundamental Nuclear Physics for Engineers. THE COLLEGE OF TECHNOLOGY, Cabot House, Ashley Down, Bristol, 7. The course is designed for engineers, physicists and industrial executives with responsibility particularly in the field of the generation of power from nuclear energy and is intended to give a basis of underlying theory in nuclear physics and its applications. Friday and Saturday, October 10 and 11. Fee (non-residential), 1 guinea.



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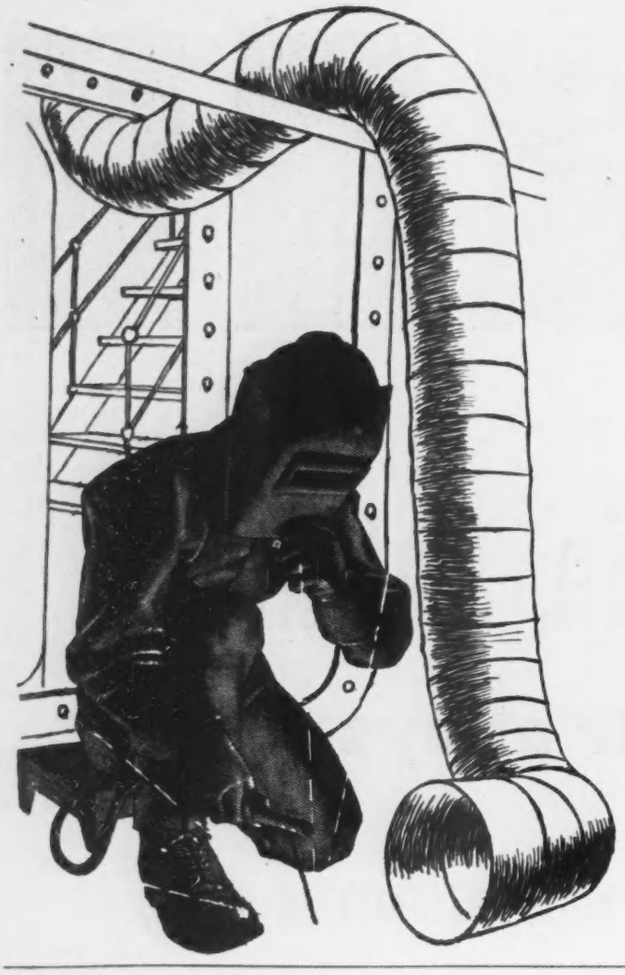

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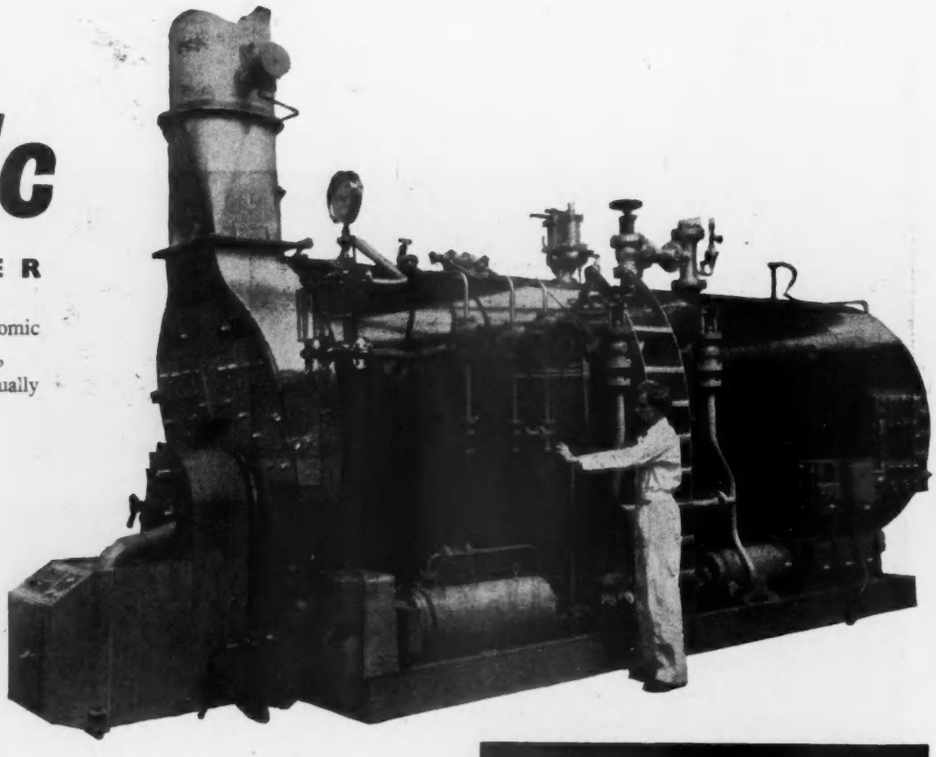

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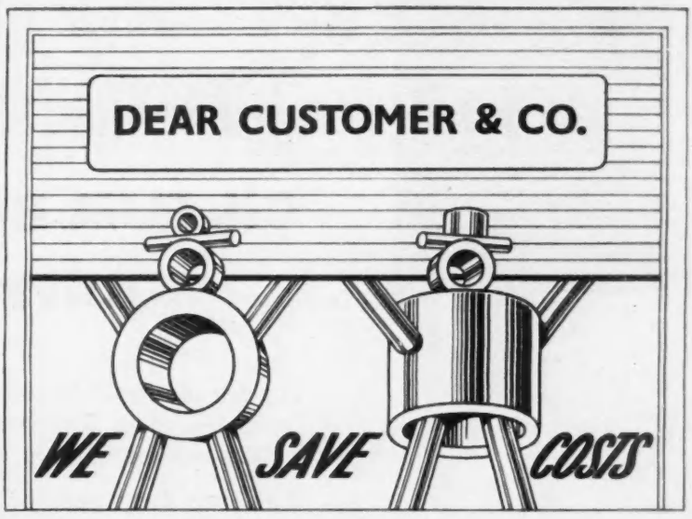

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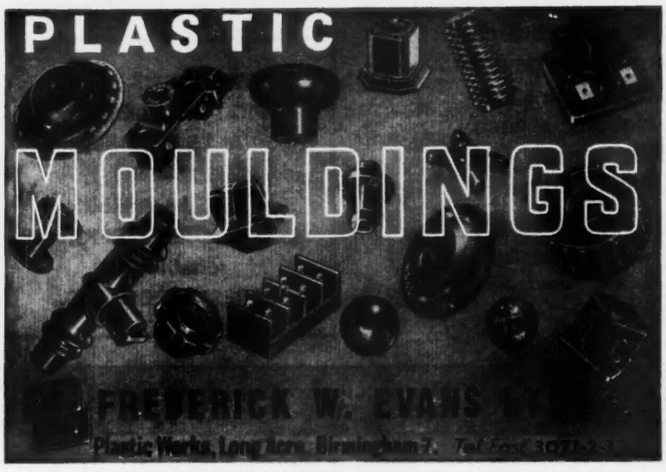

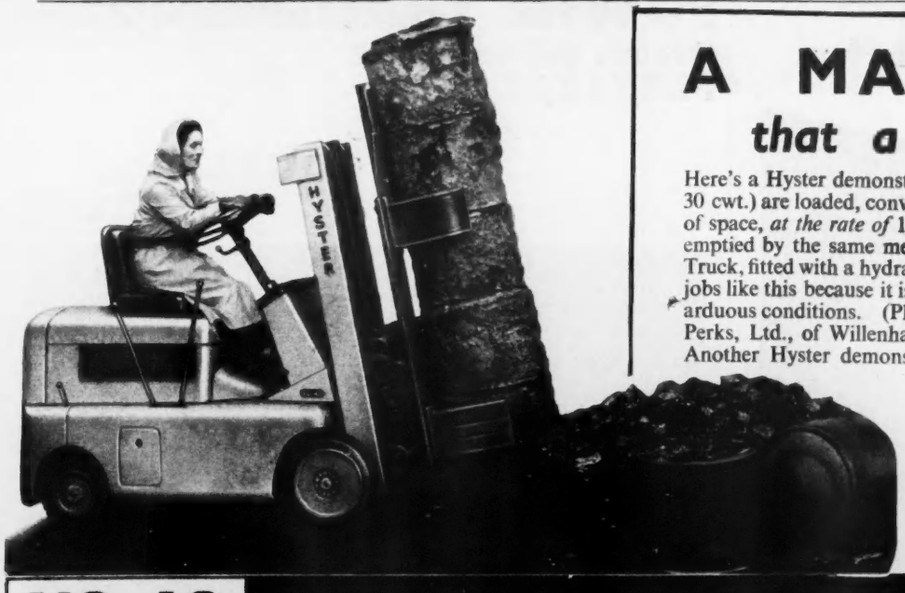

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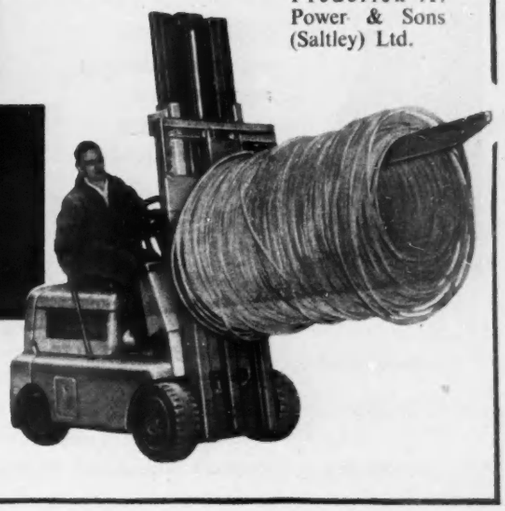

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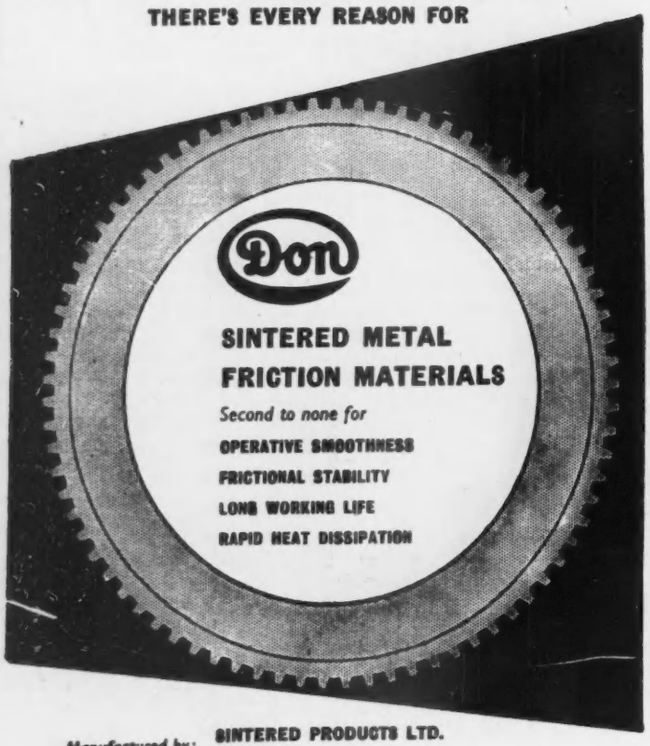

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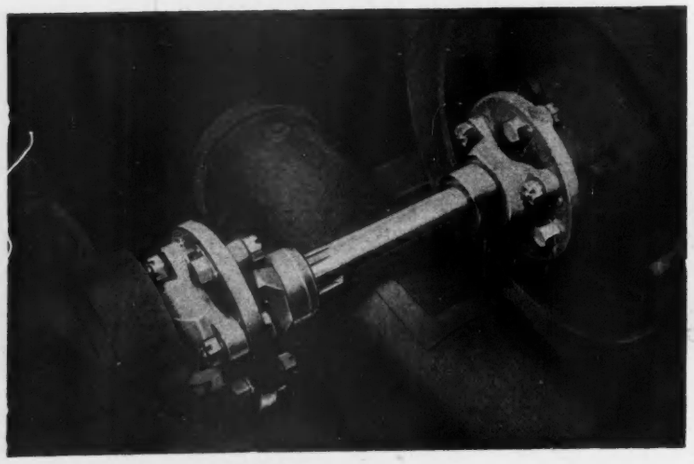

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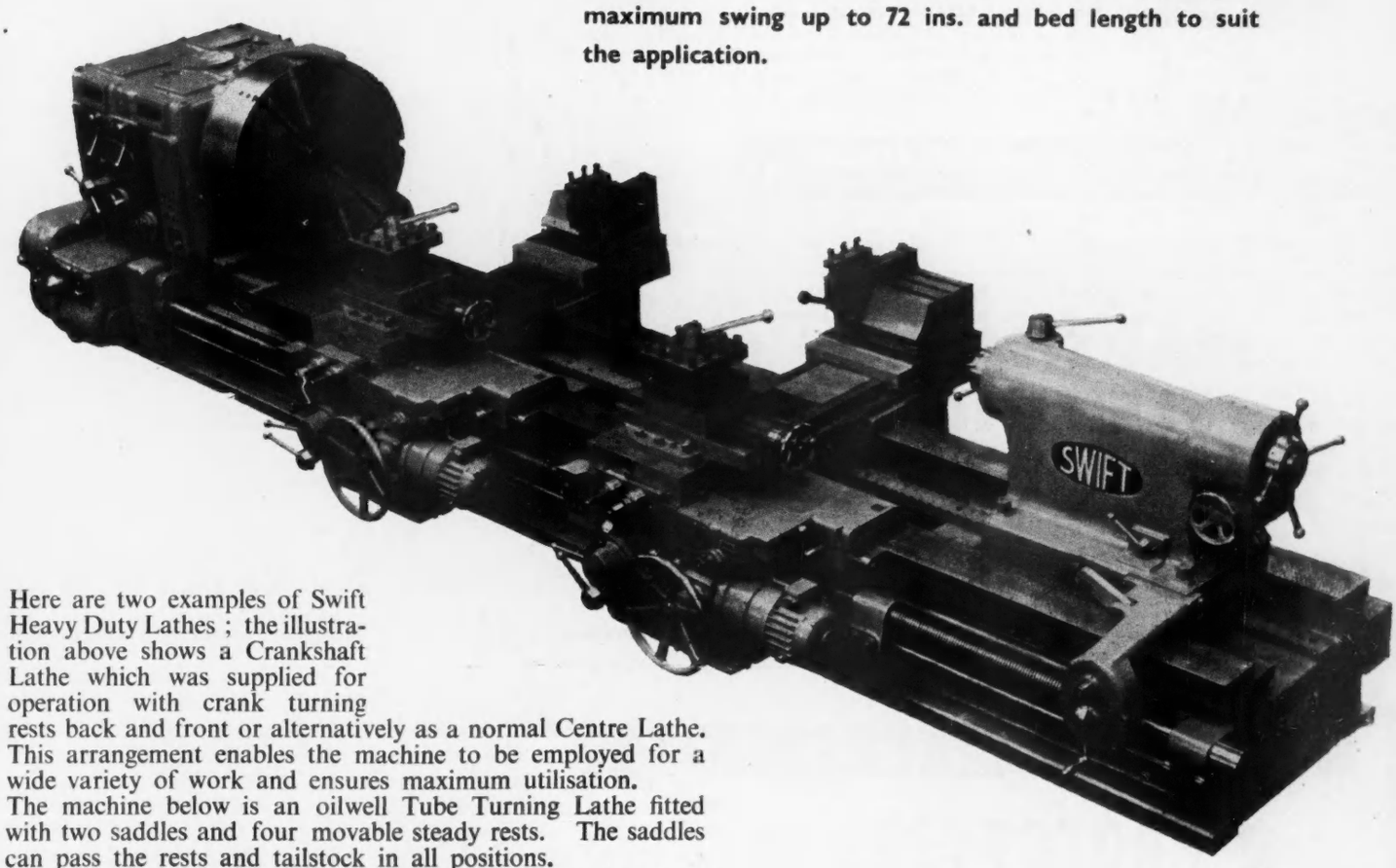

Here are two examples of Swift Heavy Duty Lathes ; the illustration above shows a Crankshaft Lathe which was supplied for operation with crank turning rests back and front or alternatively as a normal Centre Lathe. This arrangement enables the machine to be employed for a wide variety of work and ensures maximum utilisation.
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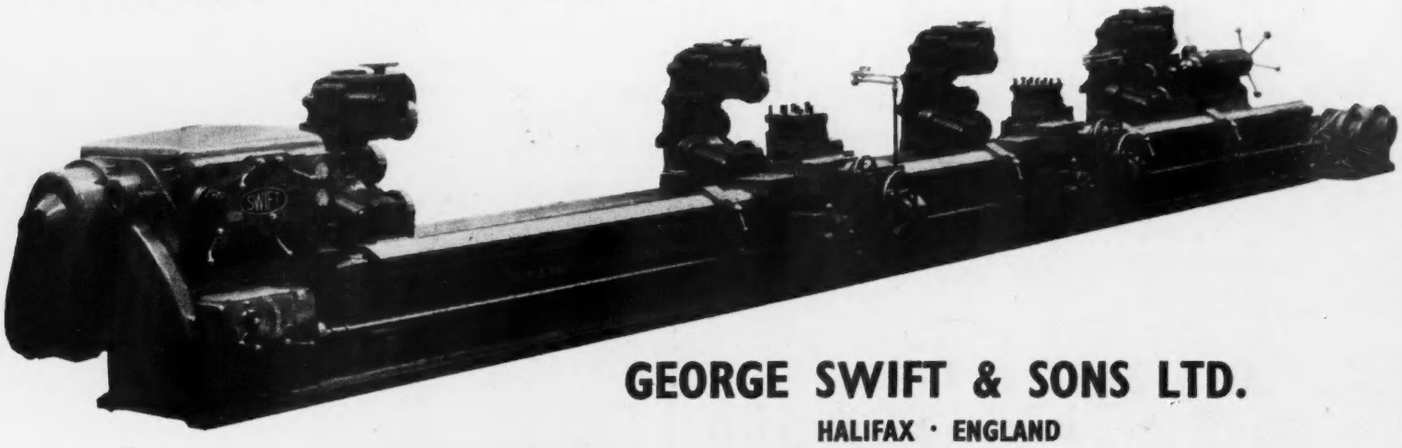

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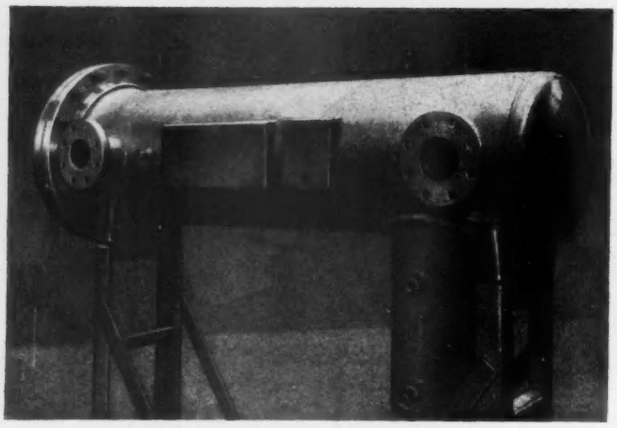

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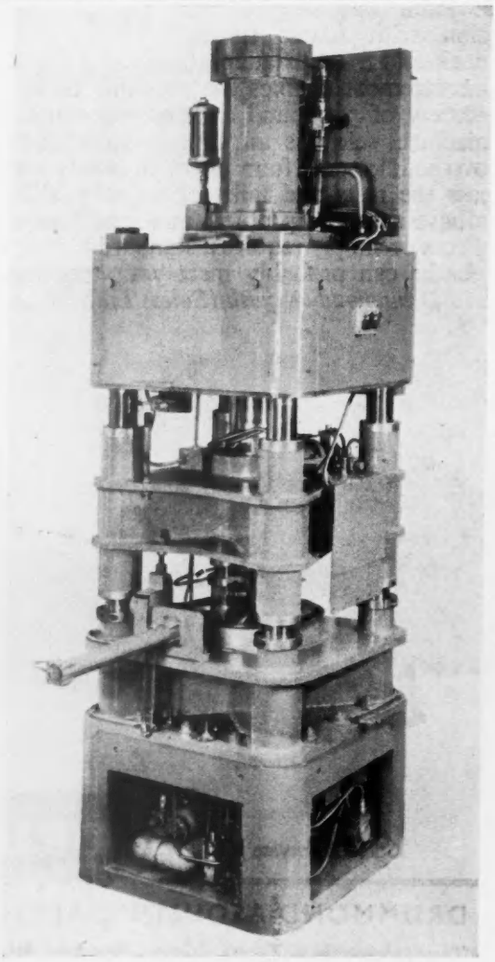

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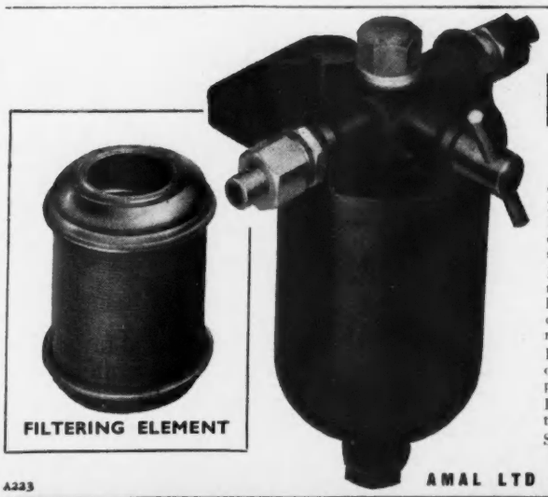

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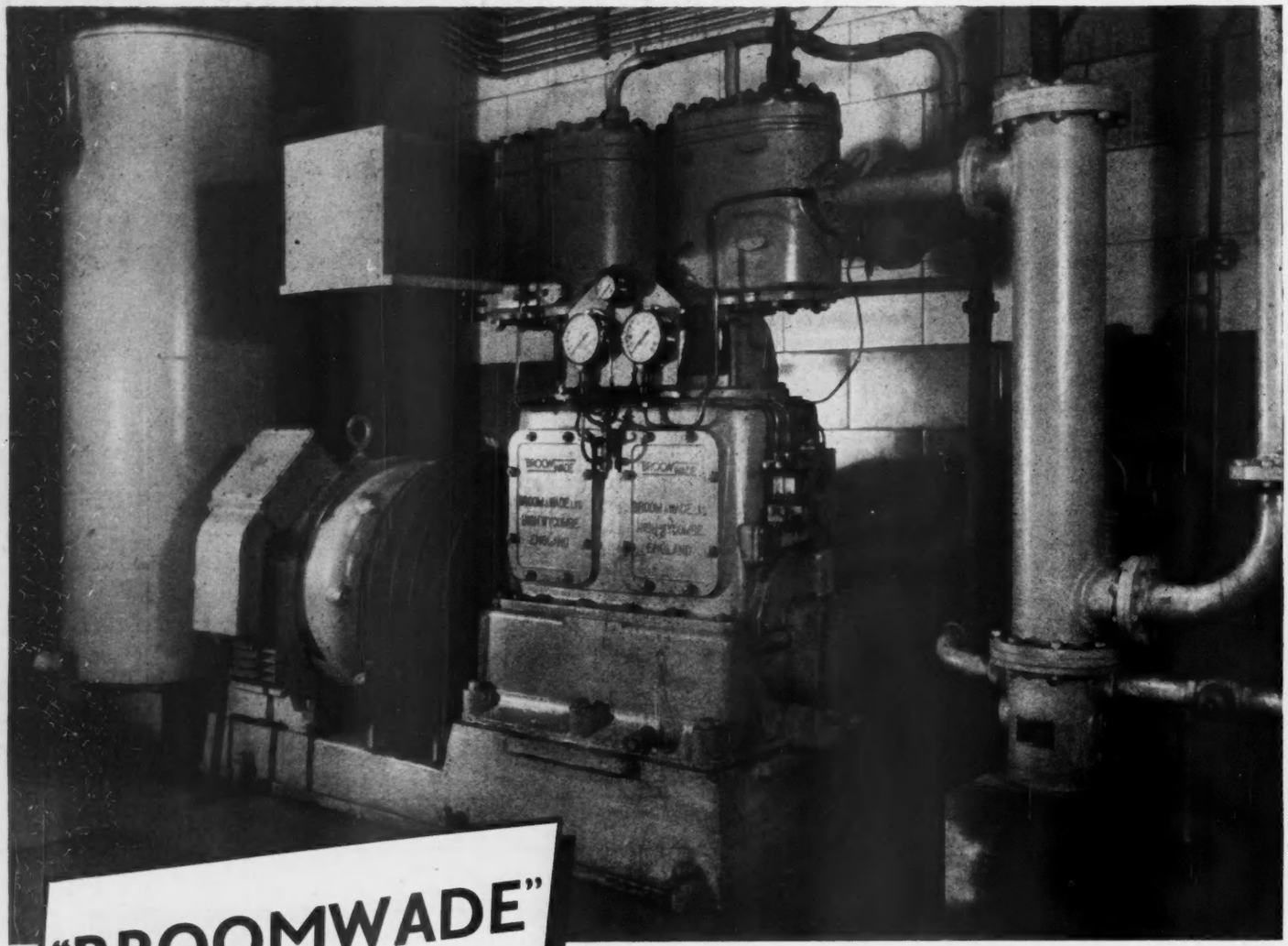

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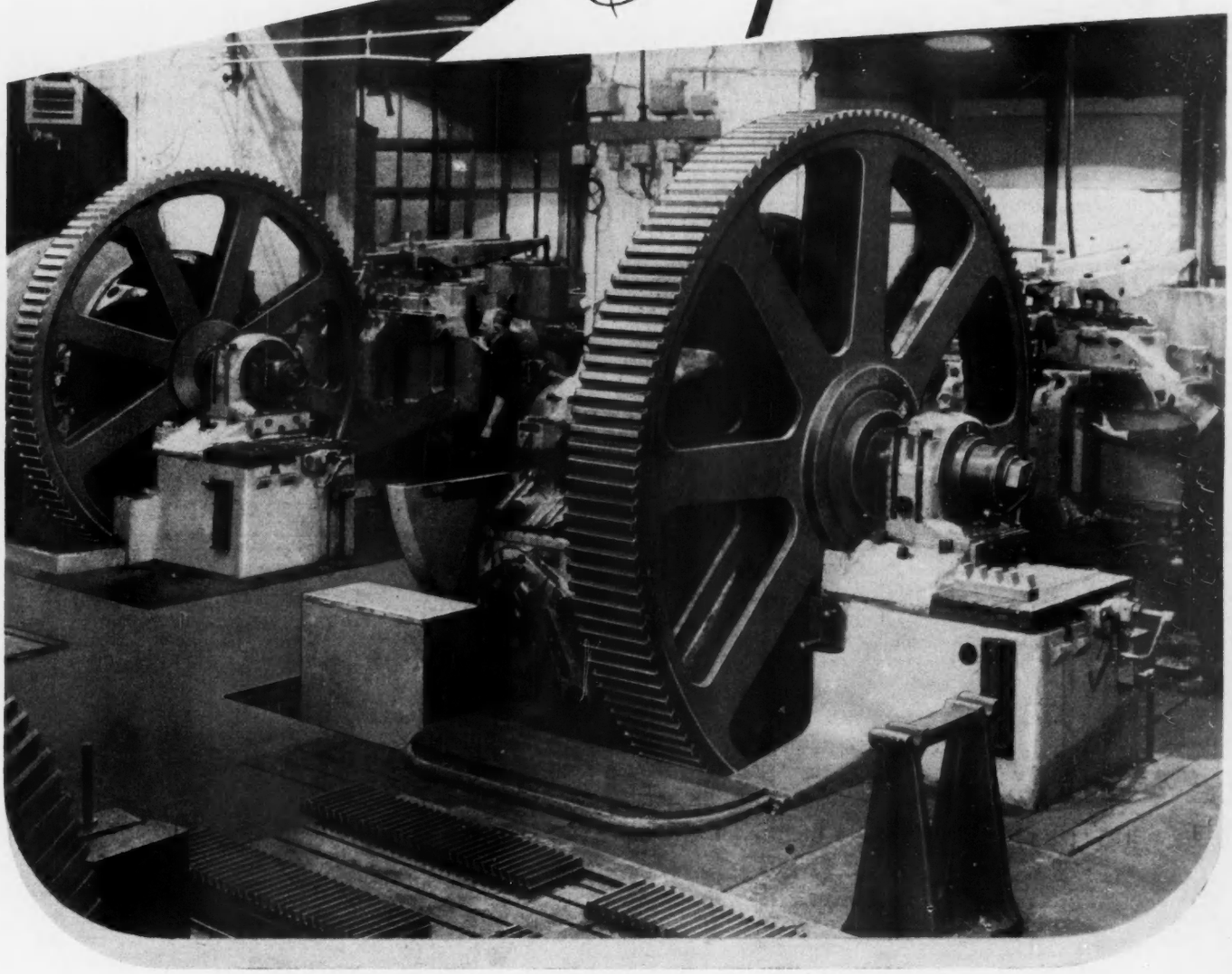

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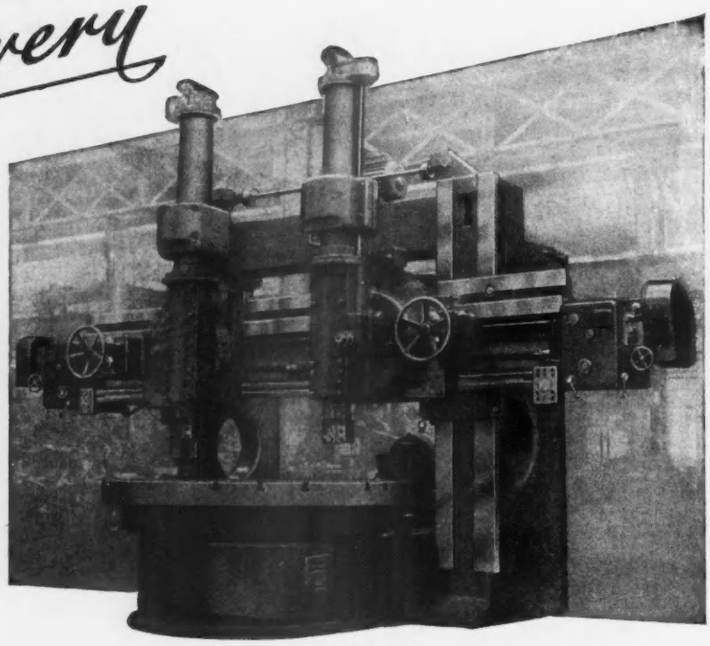

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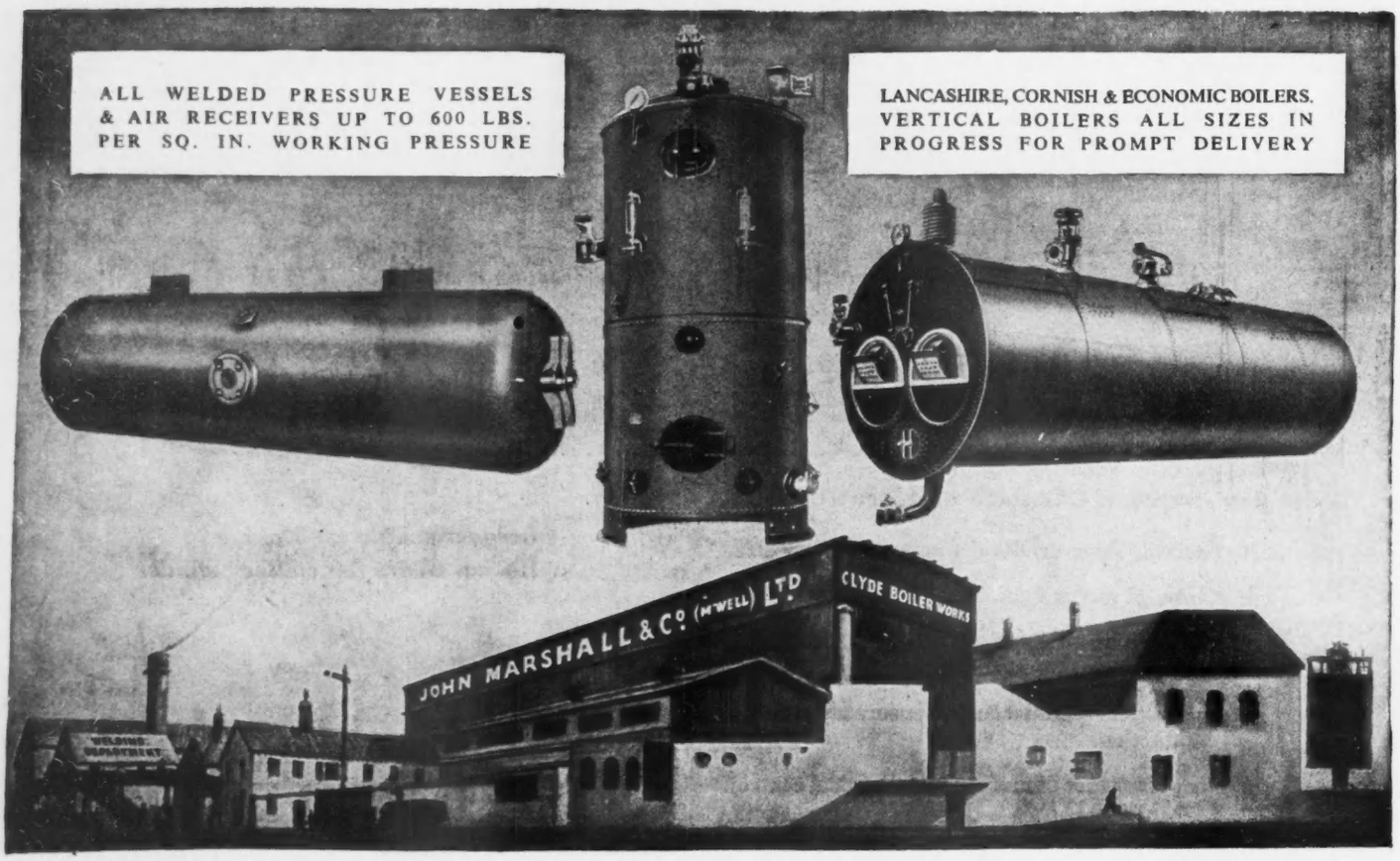

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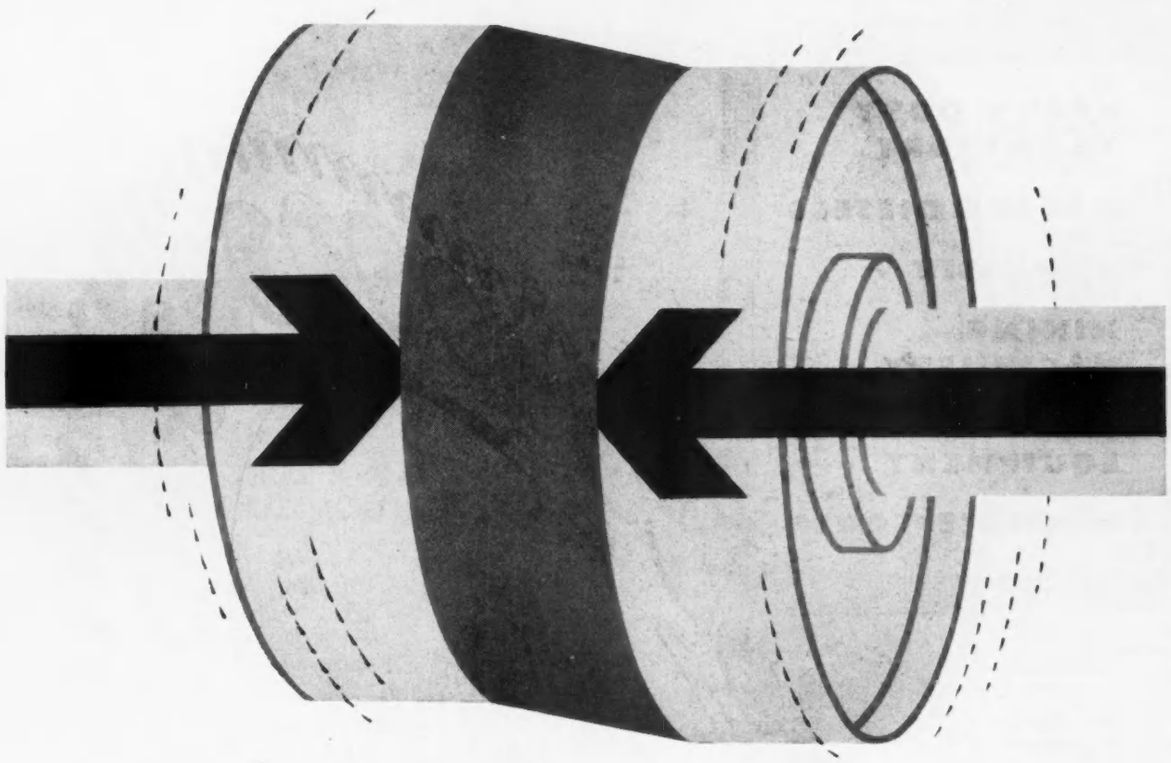

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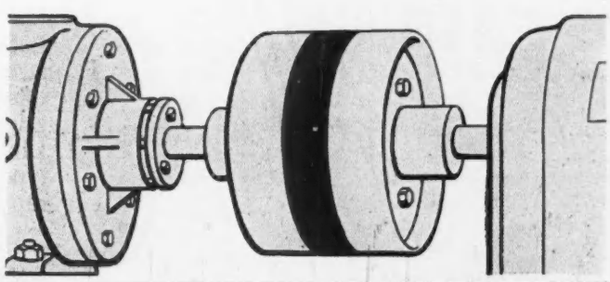

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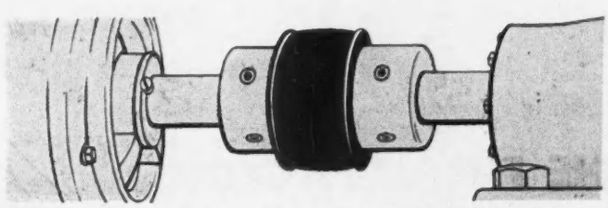

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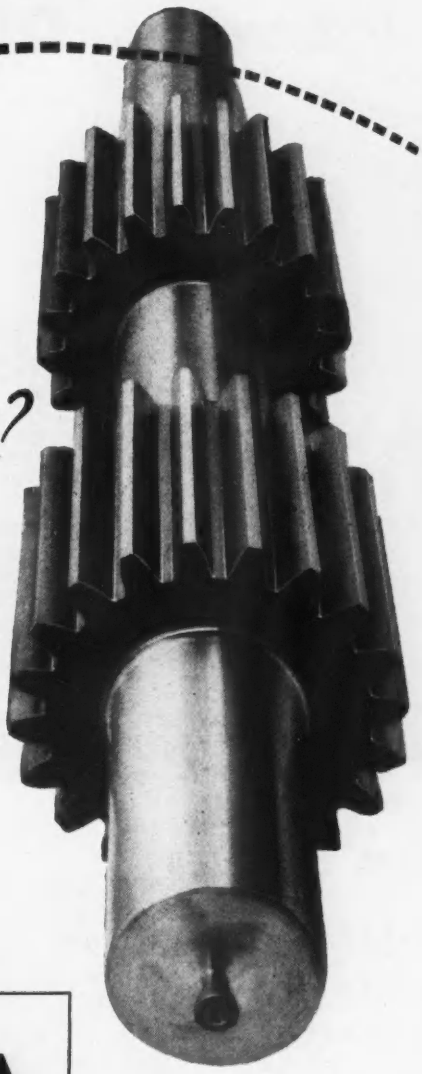

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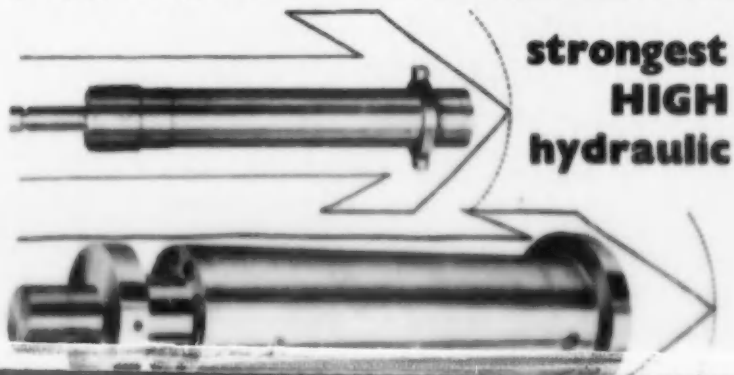

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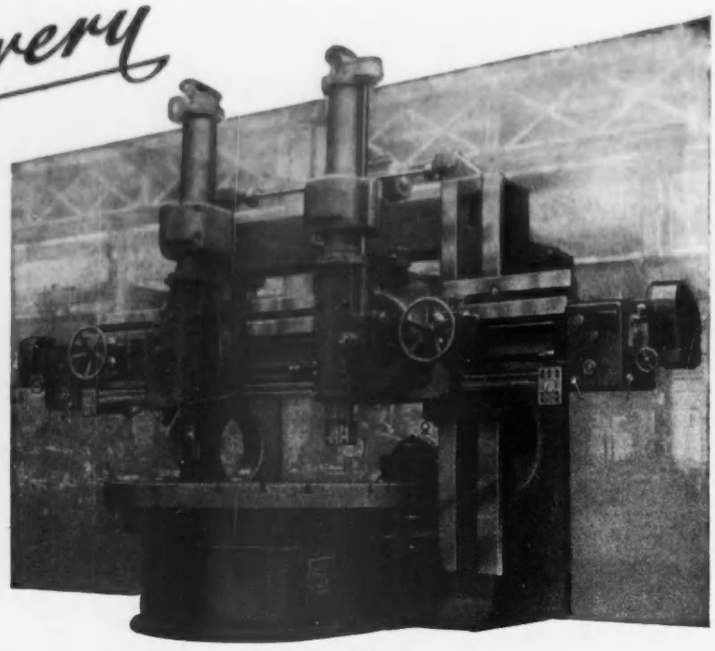

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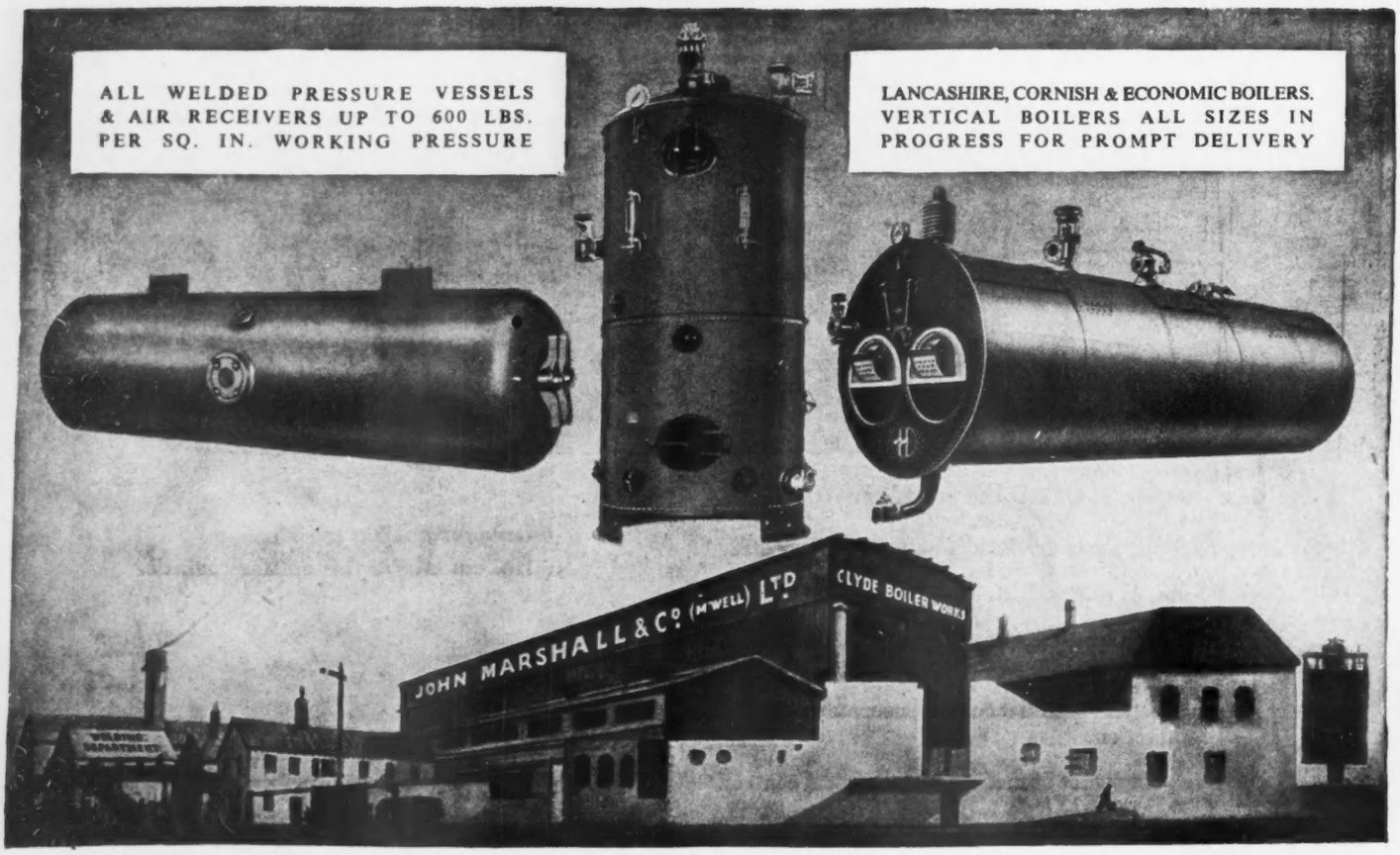

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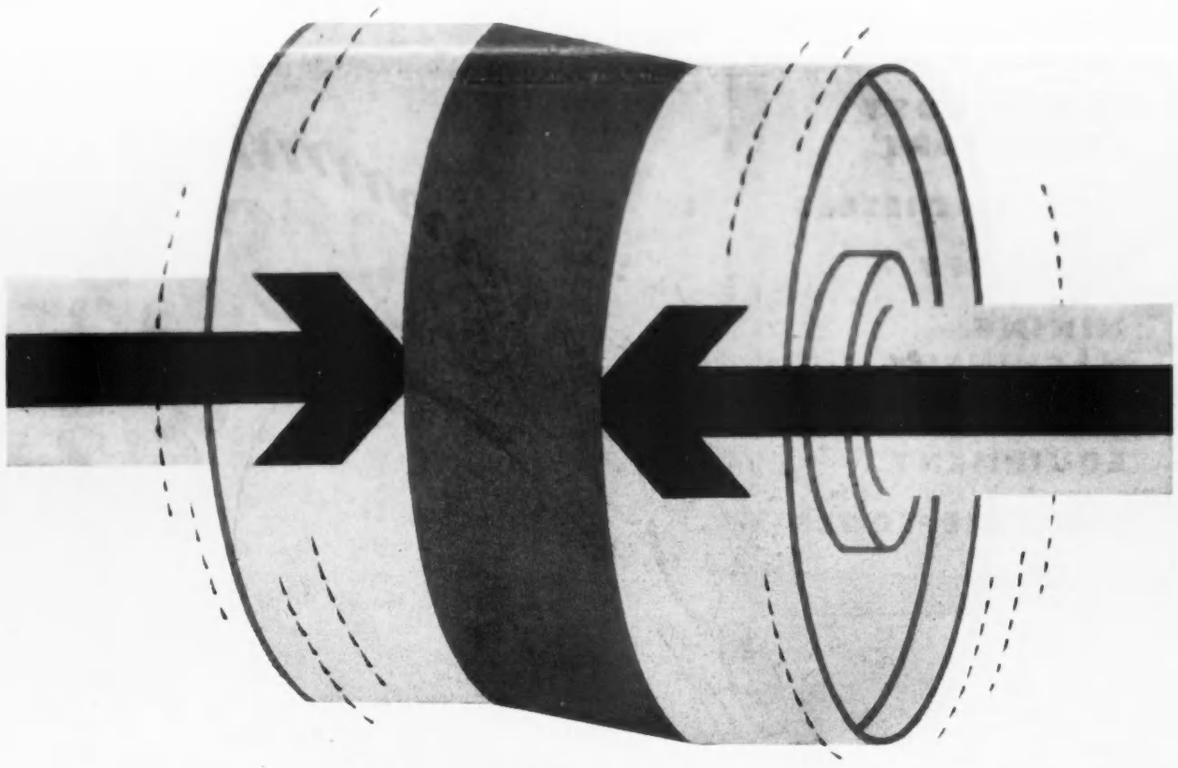

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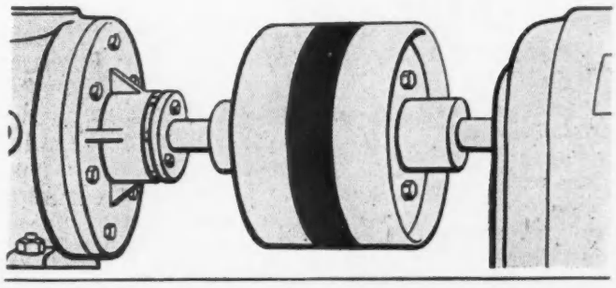

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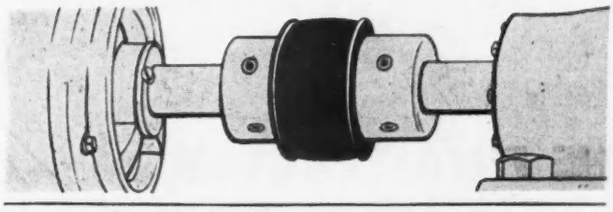

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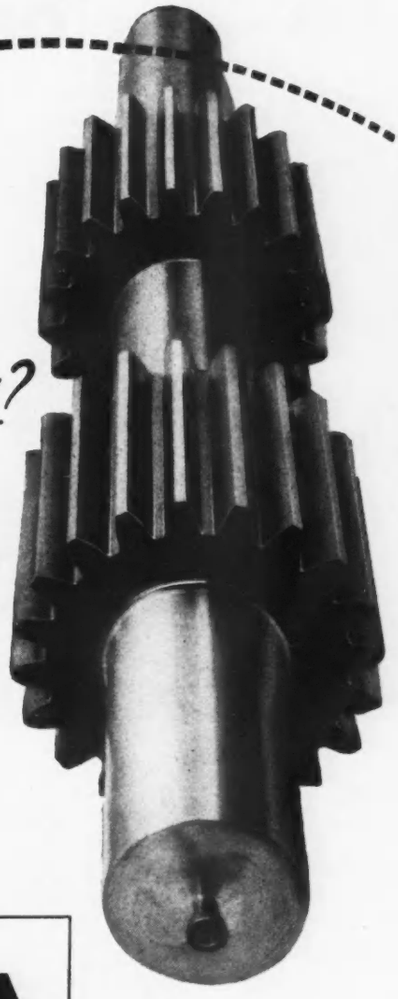

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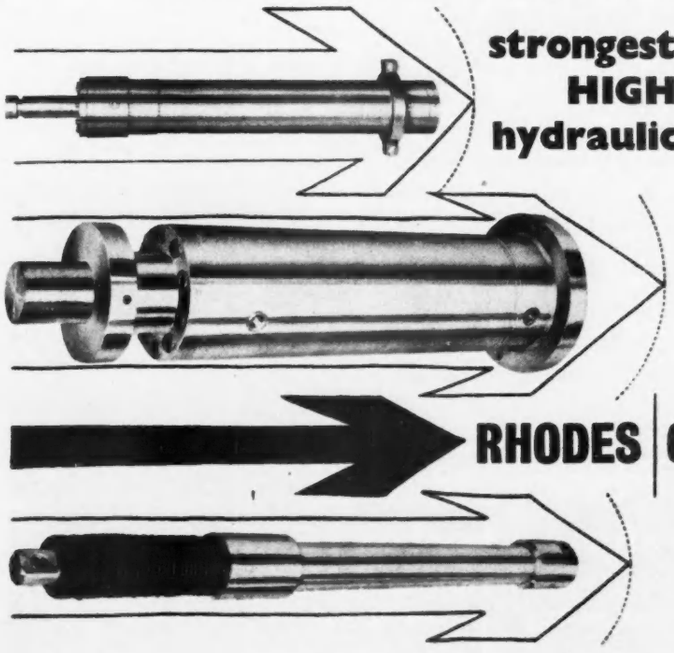

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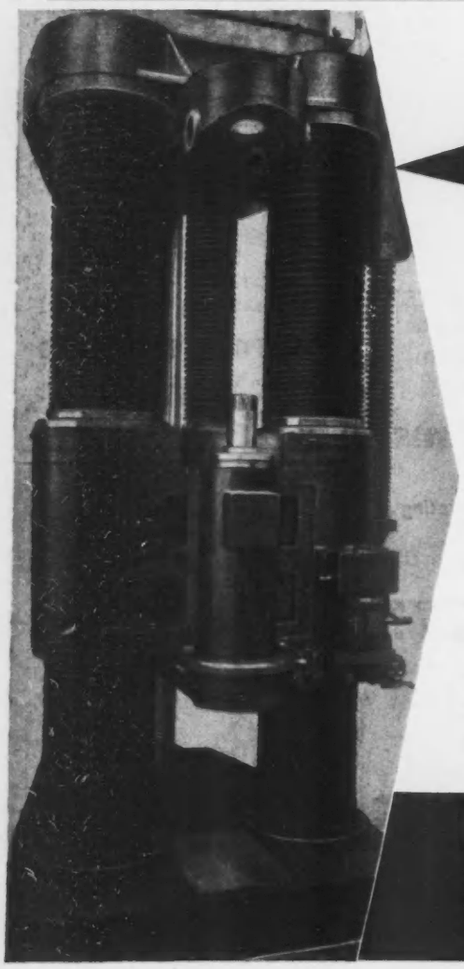

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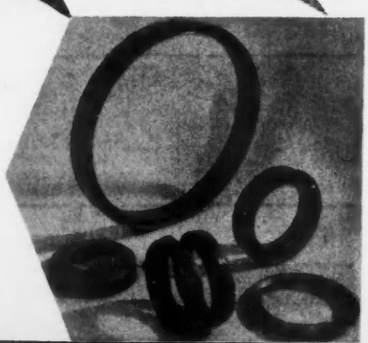

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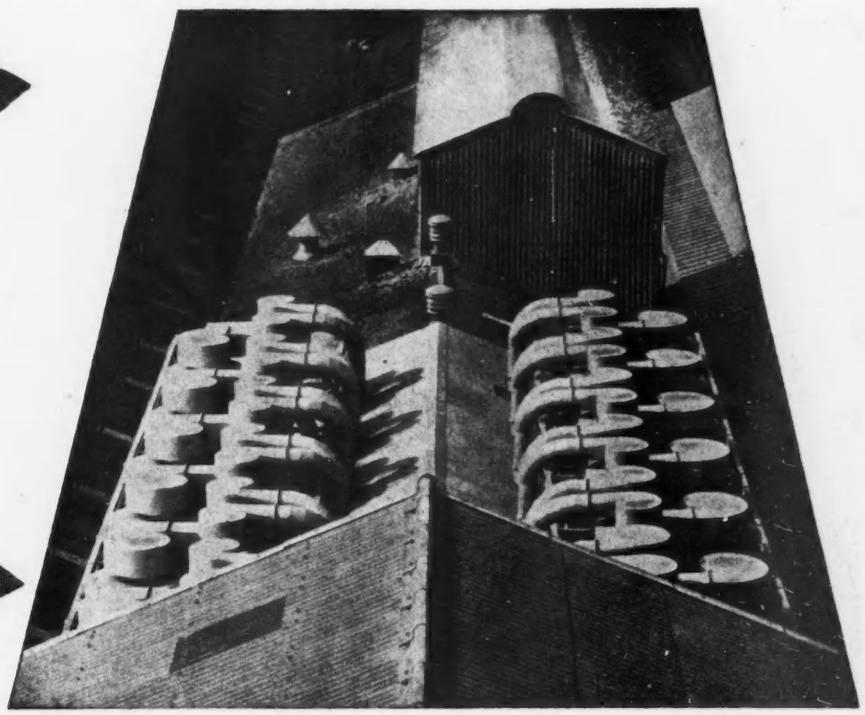

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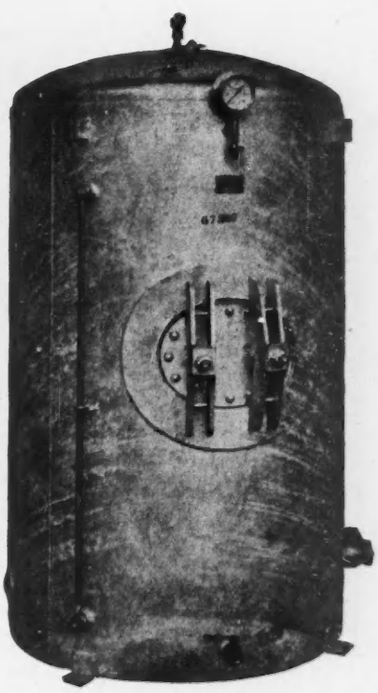

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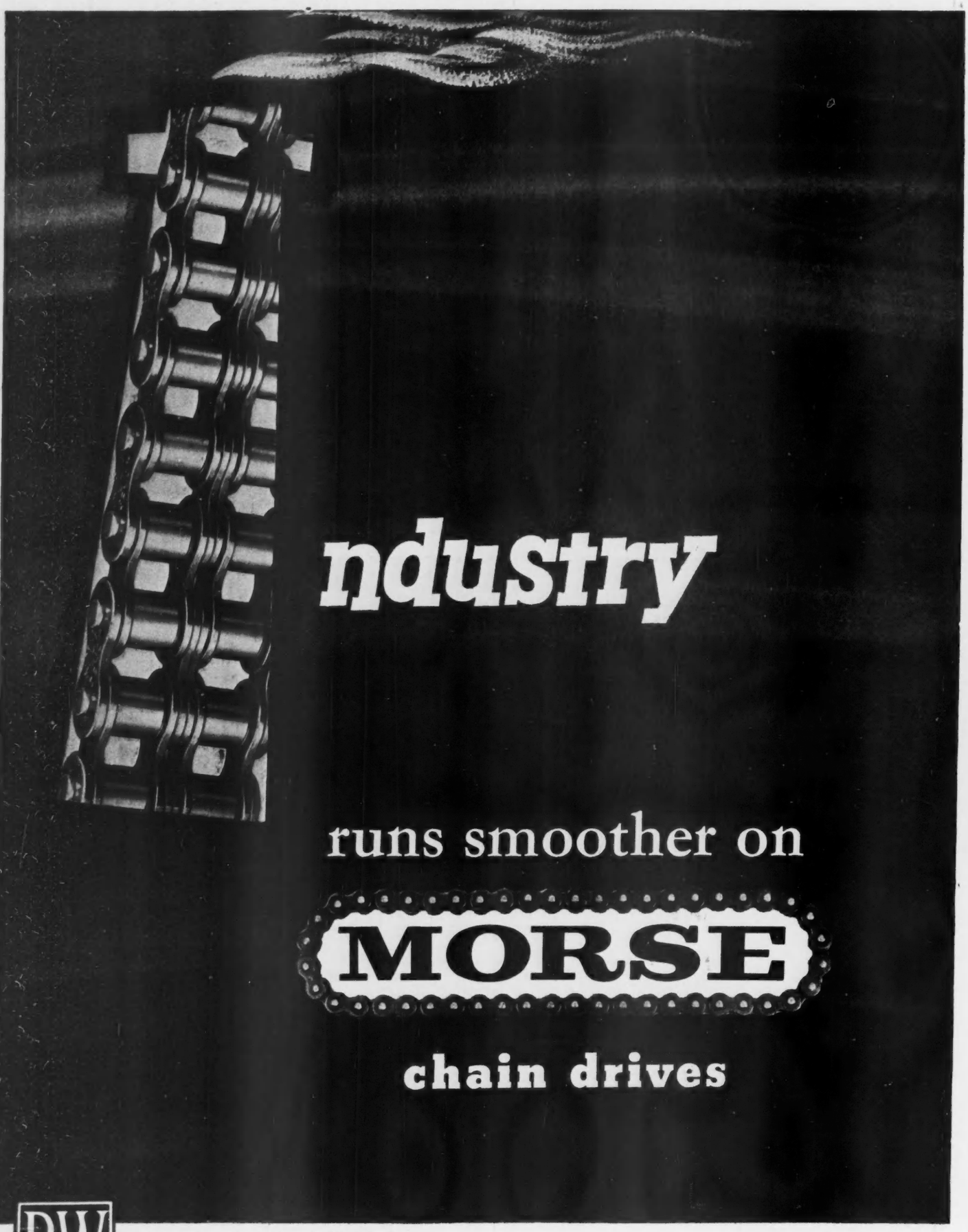

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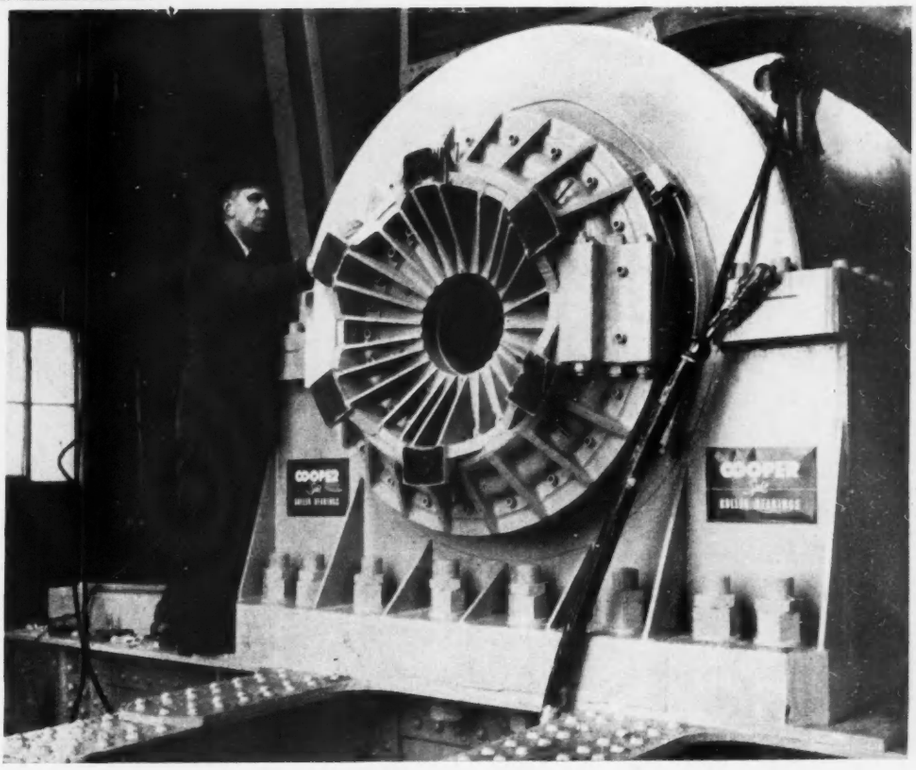

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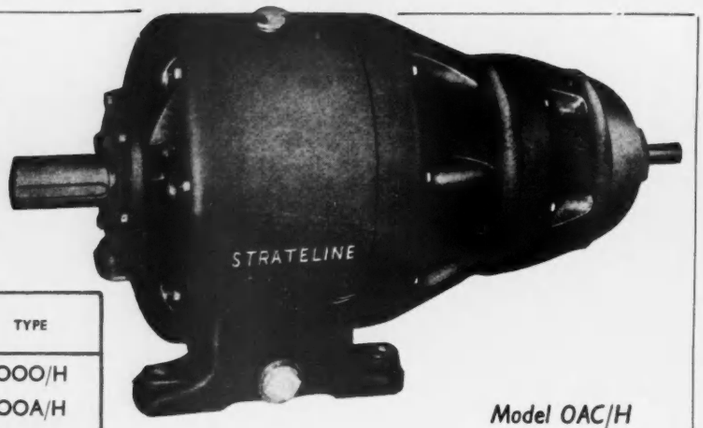
6000	6⅛	14⅜	11¾	22⅝	OAD/H
12000	7½	17	14	25 13/16	OBE/H
24000	8¾	20⅞	17	32⅝	ACF/H
48000	10¾	25½	21	39¼	ADG/H



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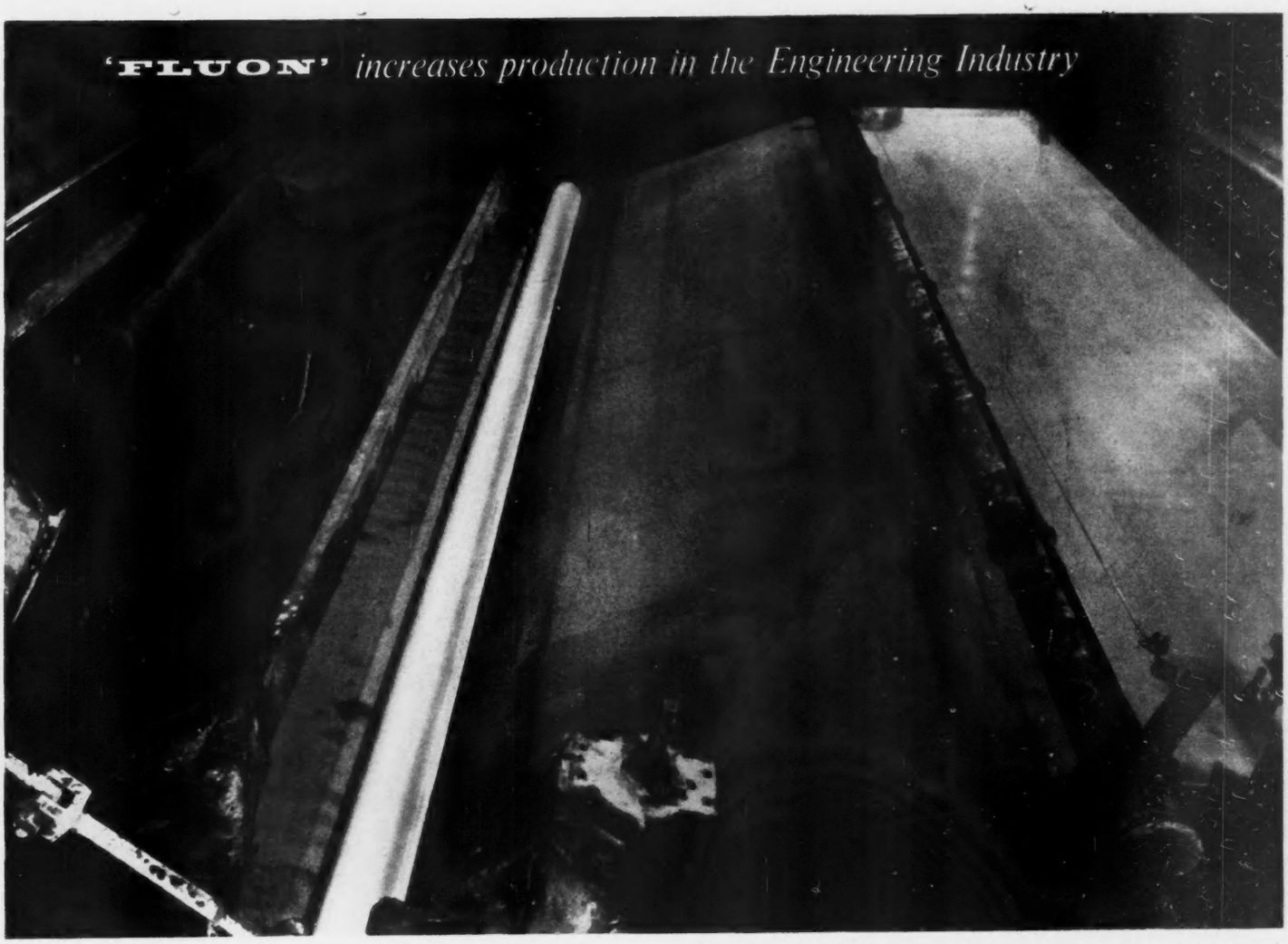

The 'Fluon' p.t.f.e. covered roller in position in the paper making machine, made by Walmsleys (Bury) Ltd.

'Fluon' sleevings prevent breaking in paper making machine

Roller for a paper making machine covered by Siemens Edison Swan Ltd. with 'Fluon' polytetrafluoroethylene.

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'Fluon' was chosen for the holding down roll because of its non-sticking properties thereby reducing the possibility of paper breaks when the sheet leaves the Suction Couch Roll. On open paper making machines, i.e. without automatic transfer from the Wire Part to the Press Part, considerable time is saved with 'Fluon' covered rolls, and in consequence prevents loss of production and increased cost.

The machine illustrated has now been running for some time with a 'Fluon' covered roll, which has proved so successful that a further roll has been ordered for a wider and faster machine. This roll will be installed in the very near future. Even though it is intended to convert the machine illustrated from an open type to a suction pick-up in the near future, a 'Fluon' covered roll was installed because of the overall saving it makes even over a short period.

'Fluon' is a tough, flexible material with a wide and ever-increasing range of industrial applications. Its quite exceptional characteristics include a wide working temperature range (-80°C. to 250°C.), non-stick and non-wetting properties.

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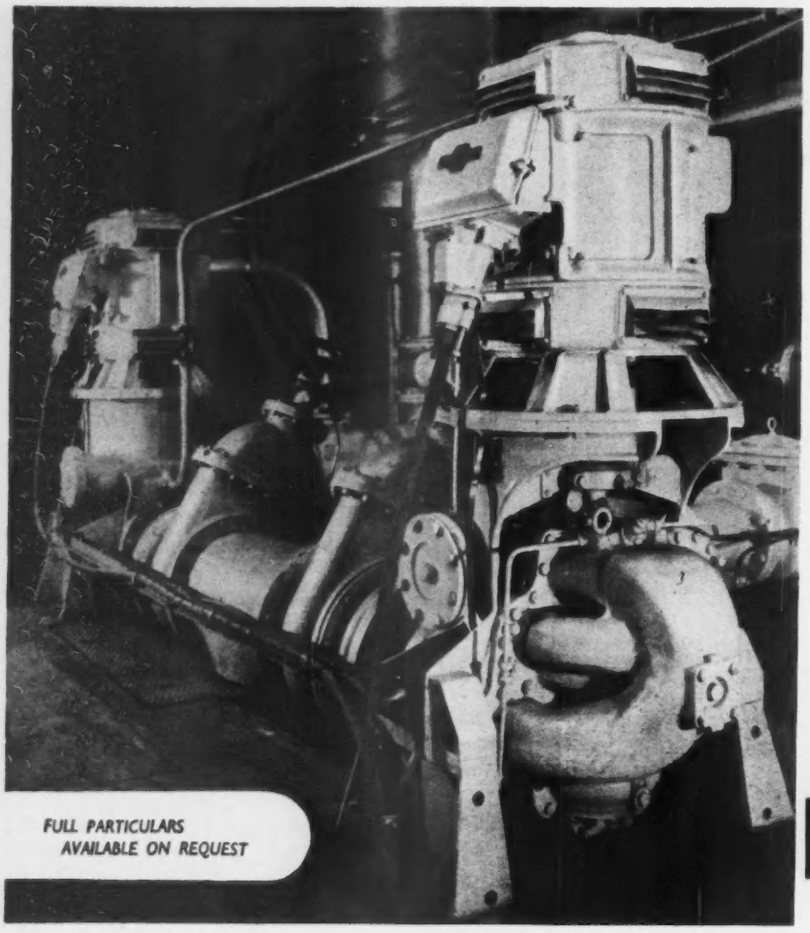

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DRYSDALE

Extraction Pumps

The Drysdale "Pervac" Pump has been designed for condensate extraction in high vacuum condensing plant where stable operation and high efficiency are fundamental requirements.

The two stage arrangement is eminently suitable for this class of work as the first stage impeller is designed for best possible vacuum, while the second stage impeller deals with external head, and its efficiency is unimpaired by consideration of vacuum.

These pumps are of the Centrifugal Split Casing type and are available in a full range of sizes and capacities in both vertical and horizontal types.

DRYSDALE & CO. LTD.
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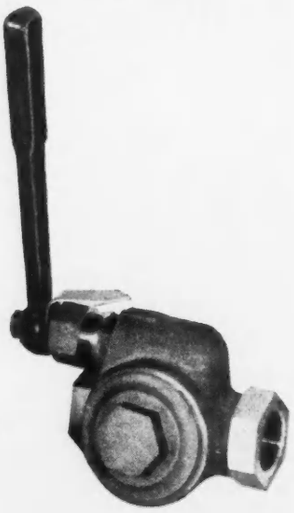
HOPKINSONS' the vital LINK

LINK valves by HOPKINSONS

There's no doubt about it—HOPKINSONS' bronze Link Valves are a vital link in all manner of industries. They handle heavy liquids such as oil and soap lines without loss of fluid-tightness or ease of operation. Having no easily-damaged external fittings, they are excellent on flexible compressed-air lines. They give long trouble-free service when handling process steam and all non-corrosive liquids. Whatever the industry there is a need for the HOPKINSON Link Valve.



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HV103

THE MORRIS *Electric* CHAIN HOIST

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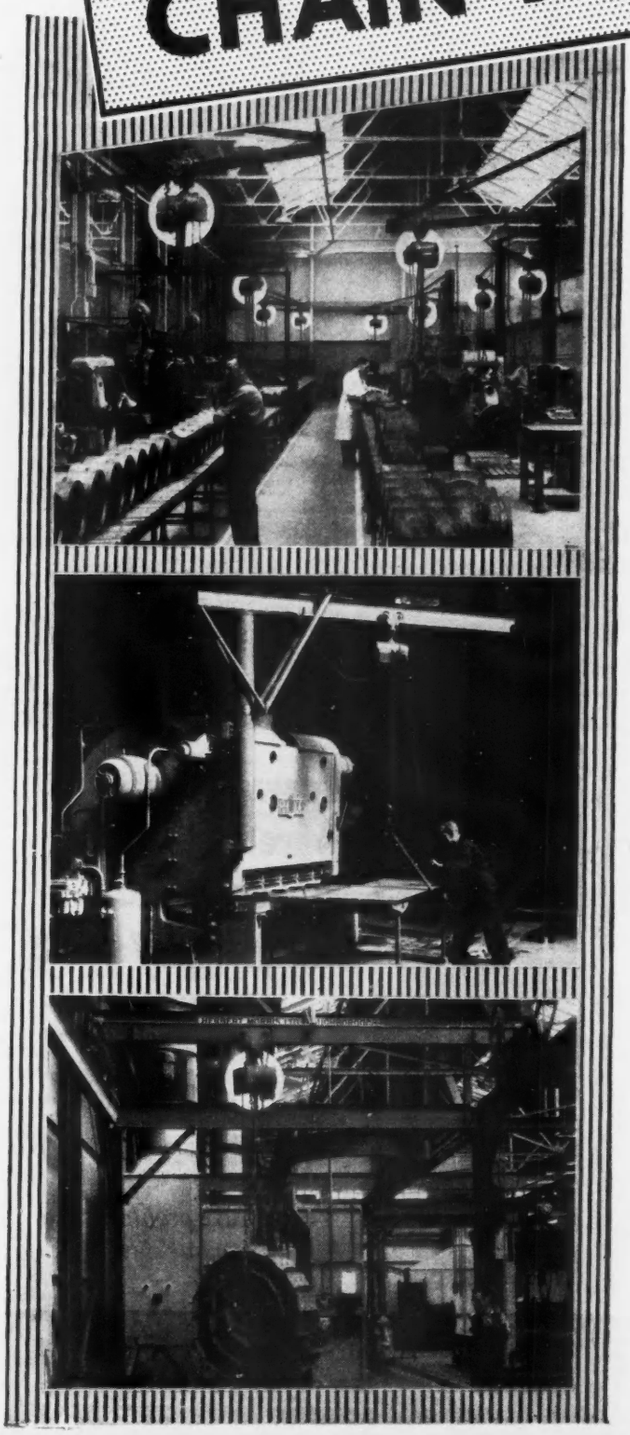

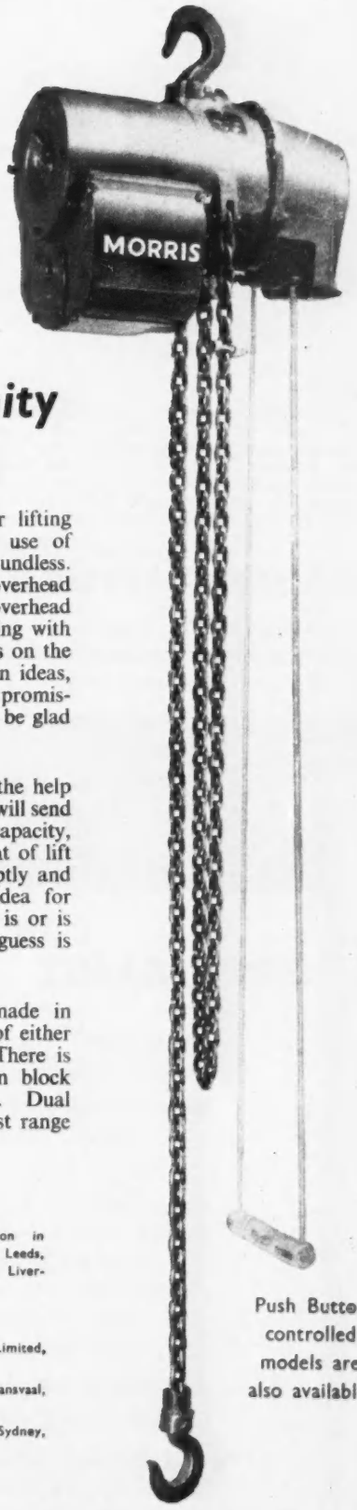

Push Button controlled models are also available.

Your opportunity to try one

The possibilities of improving your lifting facilities at moderate cost by the use of Morris electric chain hoists are boundless. Hang one of these hoists on a hand overhead crane, jib-crane, cat head, or overhead runway, and immediately, faster lifting with less effort is yours. The illustrations on the left may serve to stimulate your own ideas, and if you would like to try out some promising application right now, we would be glad to send you a hoist *on approval*.

Select a suitable type of hoist with the help of our folder Section 80/3 (which we will send you on request), let us know the capacity, electric current supply and the height of lift required, and you can decide promptly and on the spot whether your latest idea for speeding up a routine job of lifting is or is not a practical proposition. Our guess is that it will be !

Morris electric chain hoists are made in ¼-, ½- and 1-ton sizes, in the form of either pendant or push button control. There is also available a 2-ton electric chain block which is described in Section 74/3. Dual speed units in the electric chain hoist range can be supplied when required.

Resident engineers available for consultation in London, Glasgow, Manchester, Birmingham, Leeds, Sheffield, Newcastle, Cardiff, Bristol, Dundee, Liverpool, Nottingham and Bury St. Edmunds.

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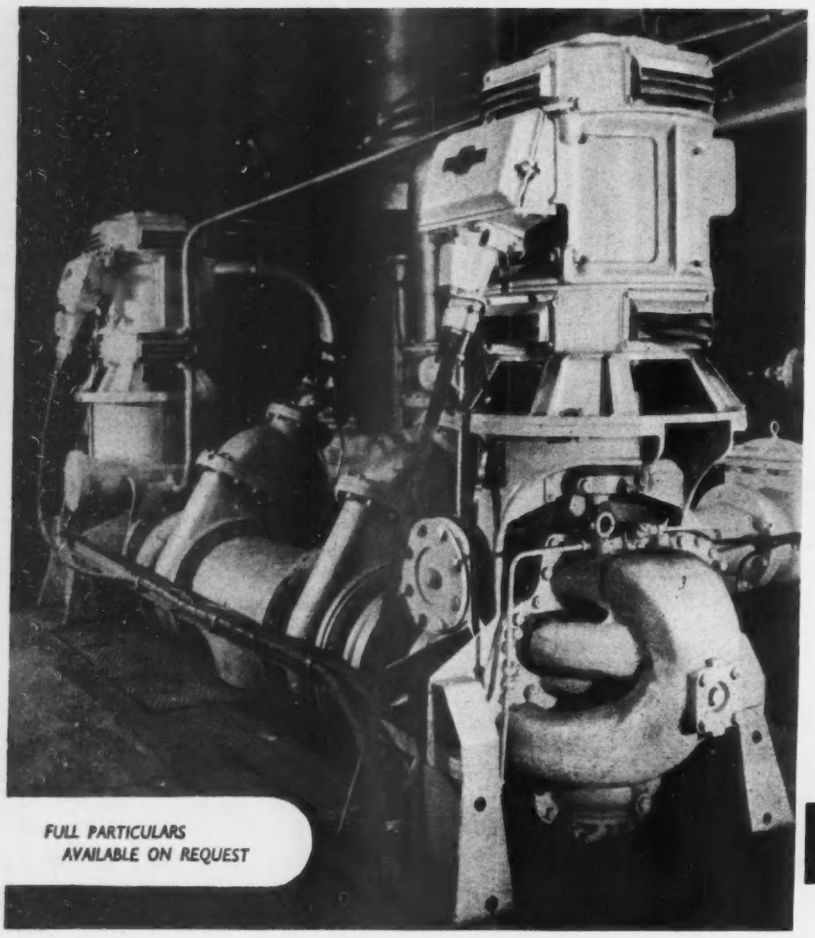

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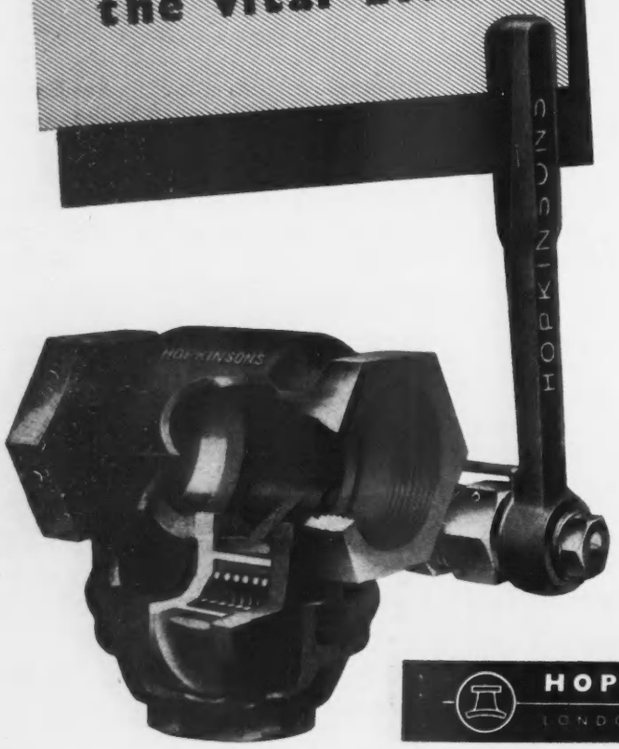

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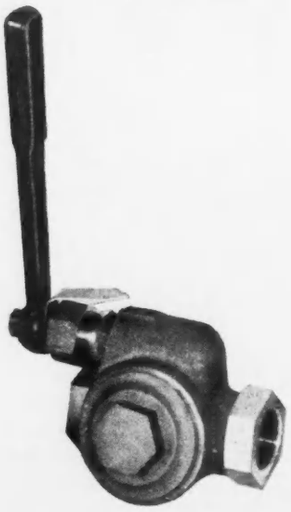

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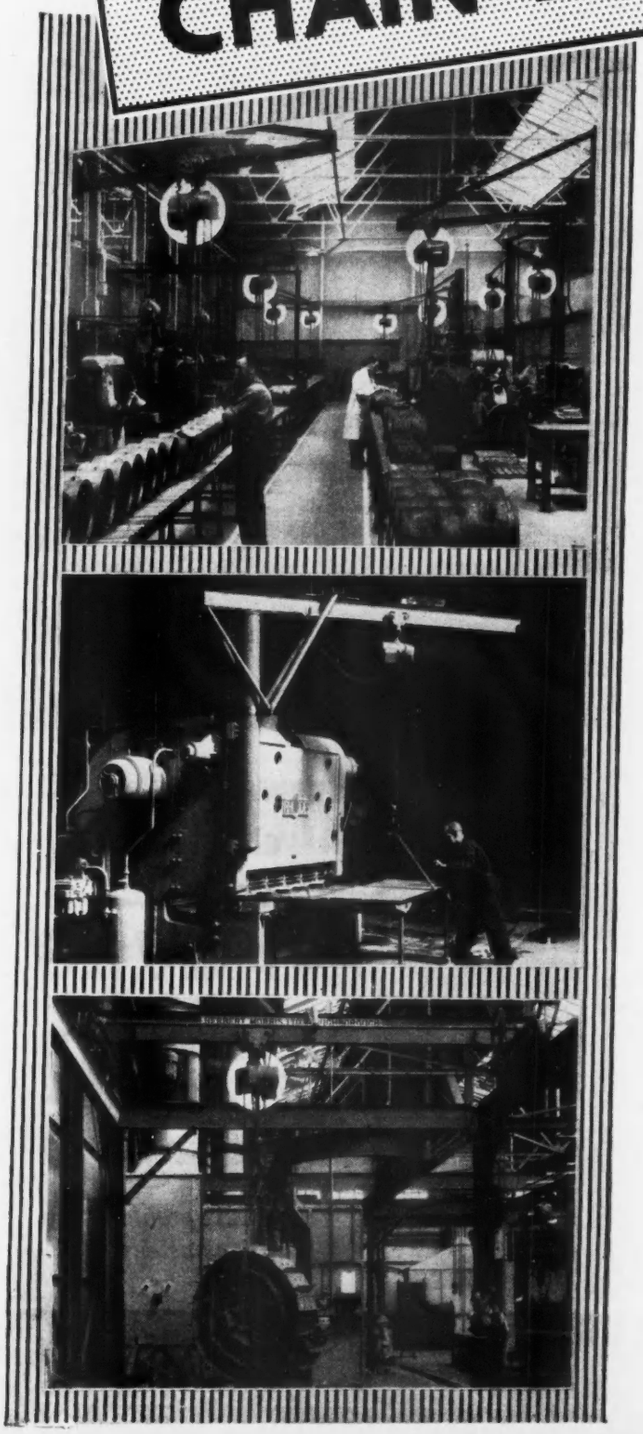

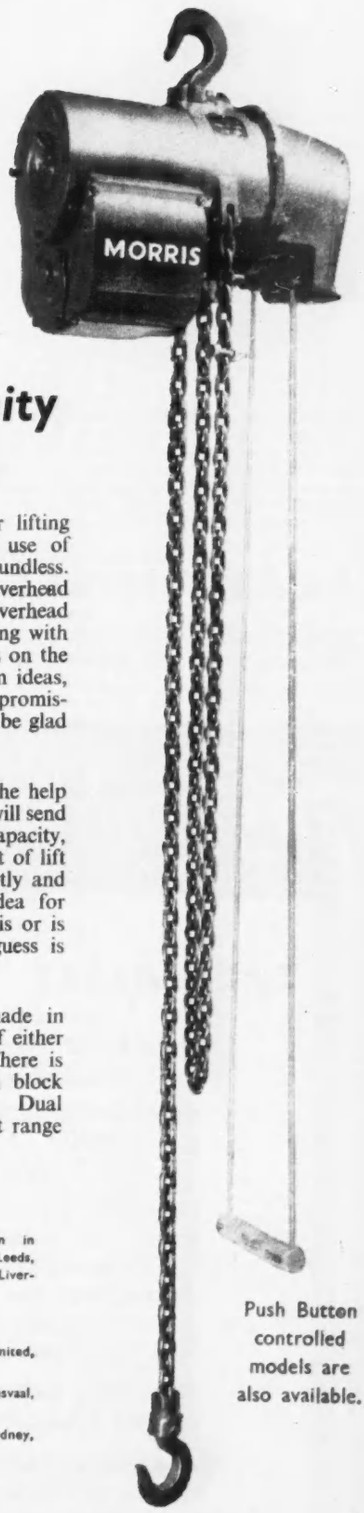

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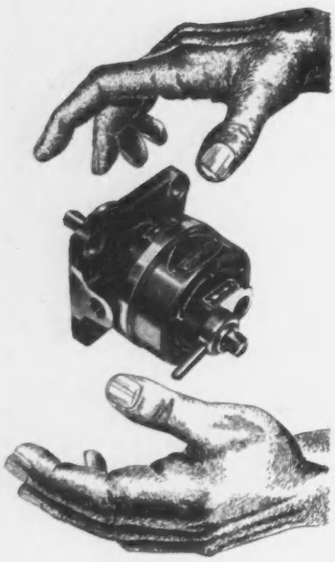

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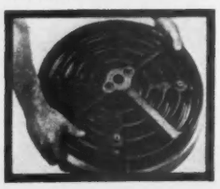

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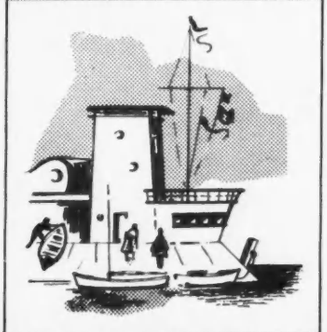

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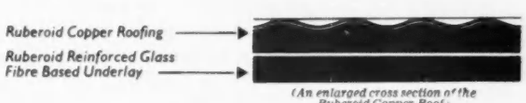

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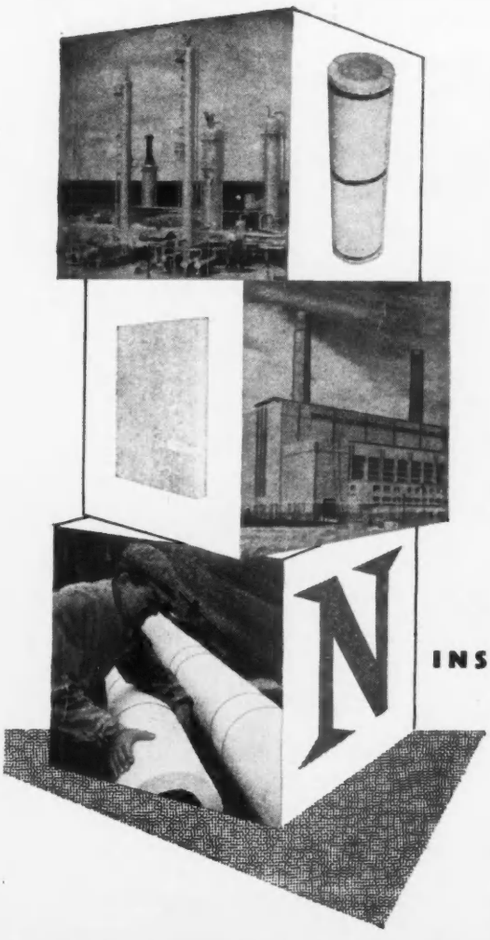

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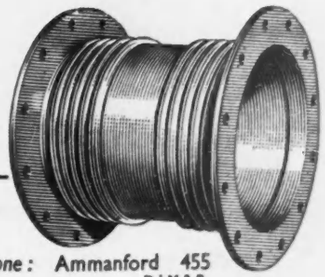

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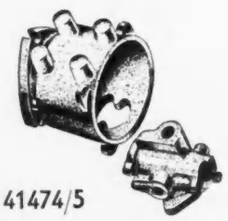

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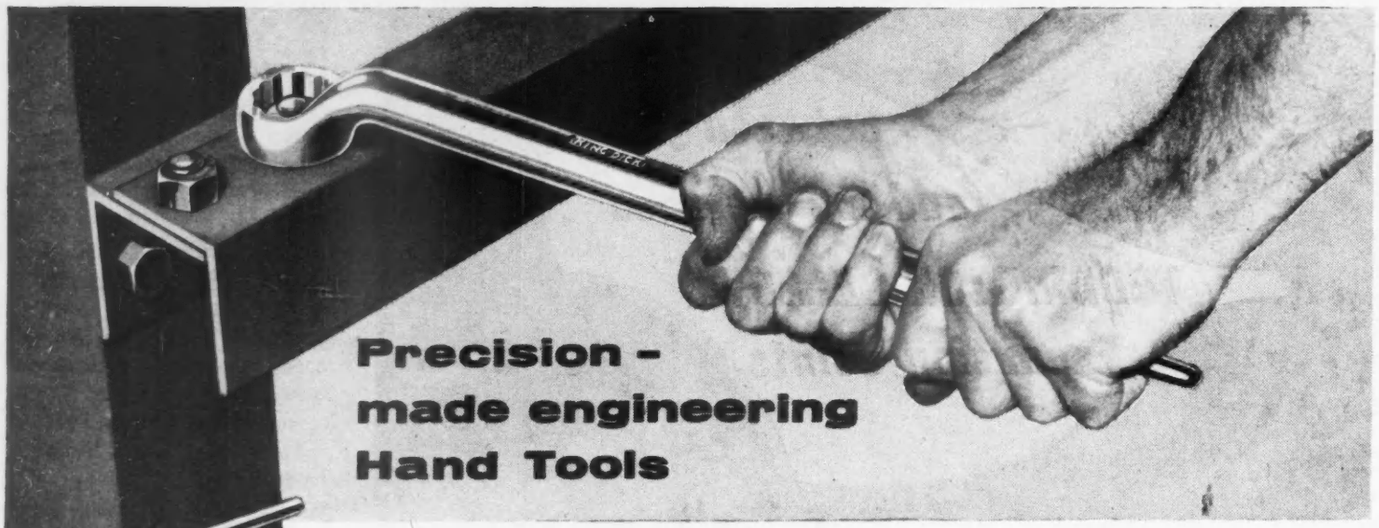

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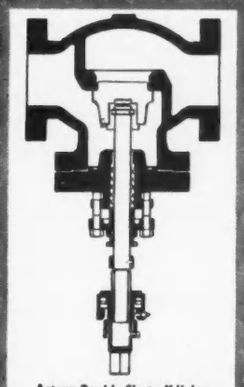
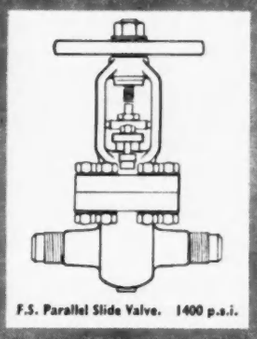
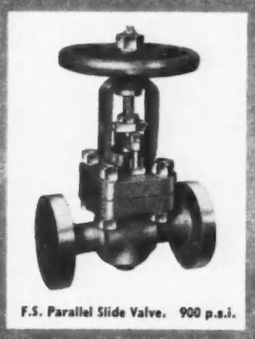
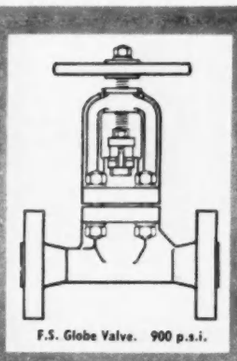
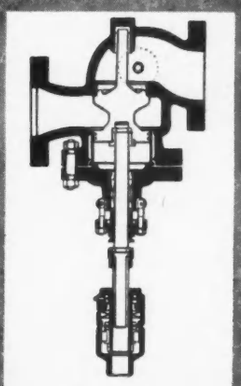
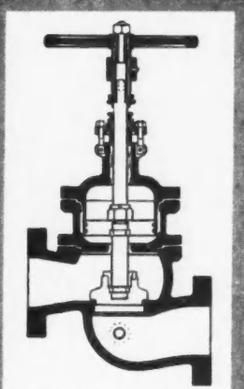

Astern Double Shut-off Valve.


F.S. Parallel Slide Valve. 1400 p.s.i.


F.S. Parallel Slide Valve. 900 p.s.i.


F.S. Globe Valve. 900 p.s.i.


Manœuvring Valve.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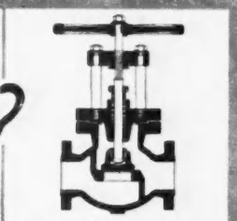
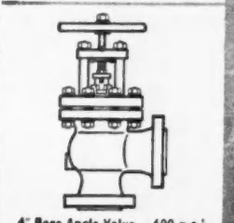
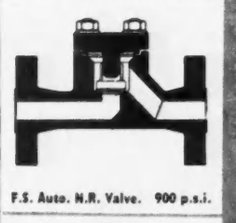

5" Bore Globe Valve. 600 p.s.i.


4" Bore Angle Valve. 600 p.s.i.


F.S. Auto. N.R. Valve. 900 p.s.i.

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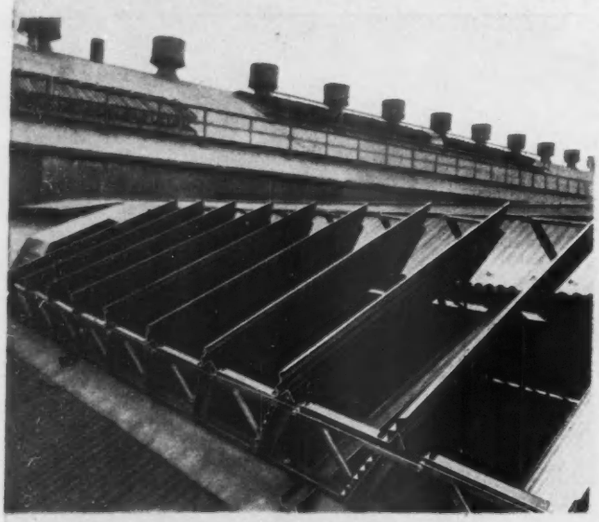
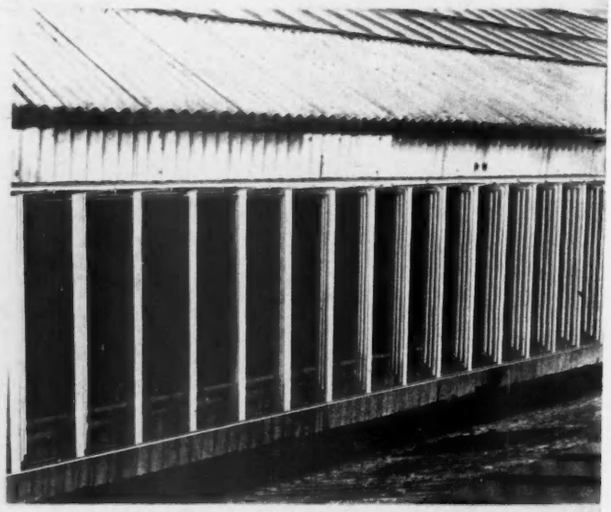
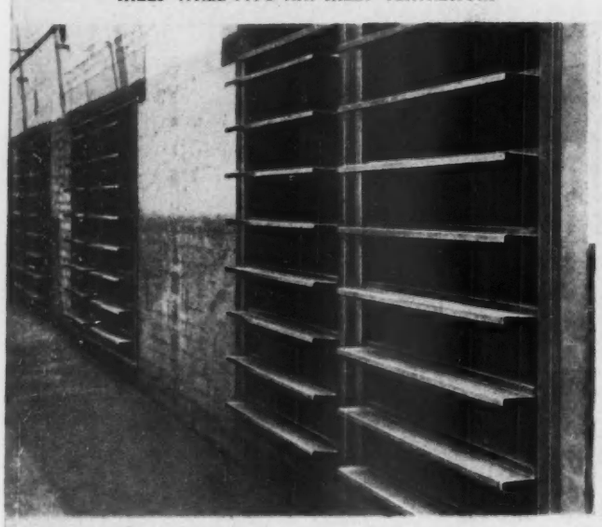


HILLS ROOF VENTILATING SHUTTERS

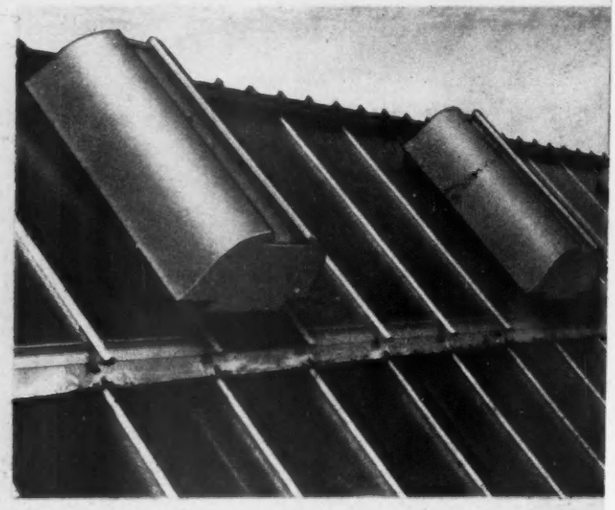


HILLS VENTILATING SHUTTERS -VERTICAL WALL APPLICATION

HILLS WALL-TYPE AIR INLET VENTILATORS



HILLS STACK ROOF VENTILATORS



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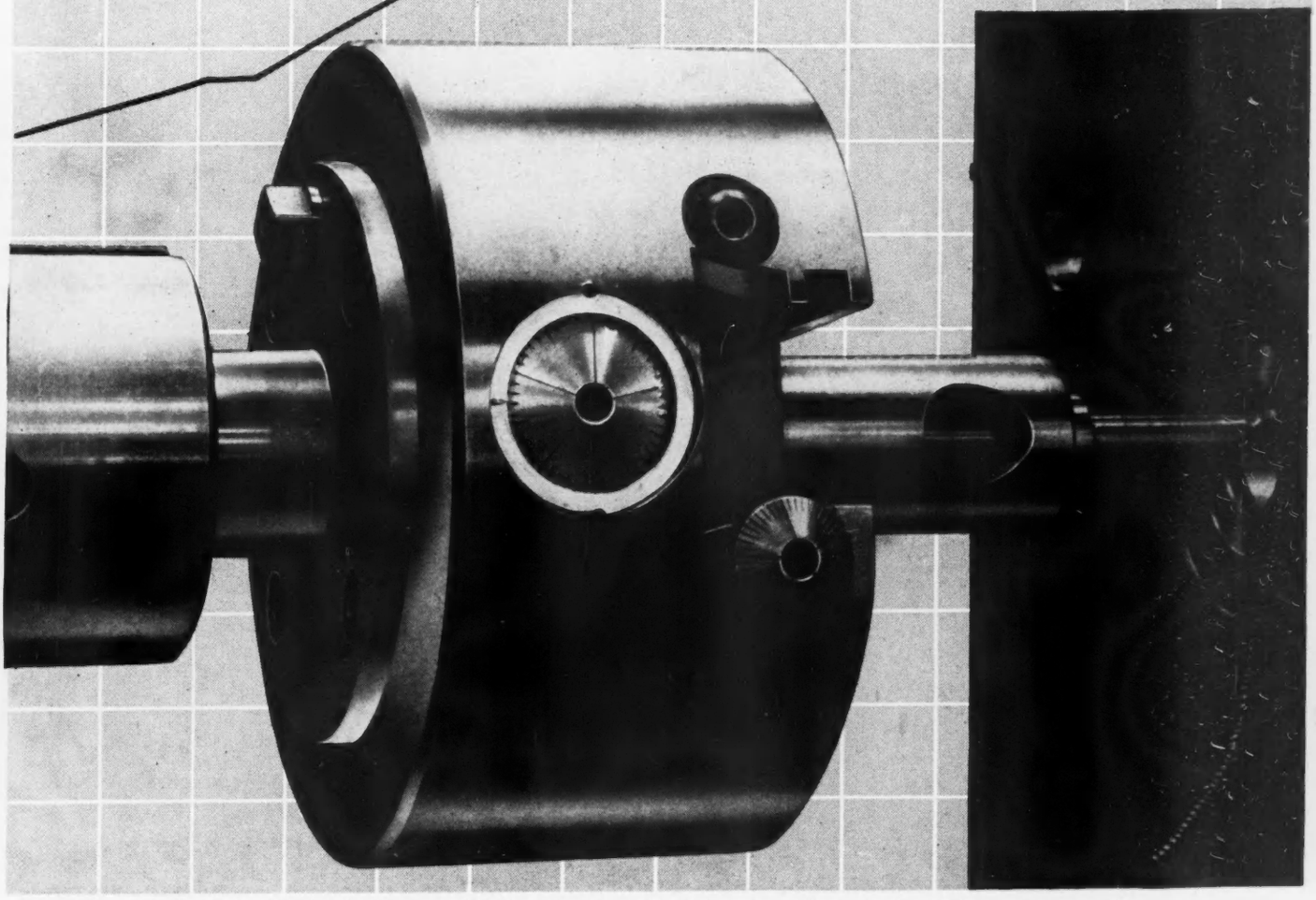

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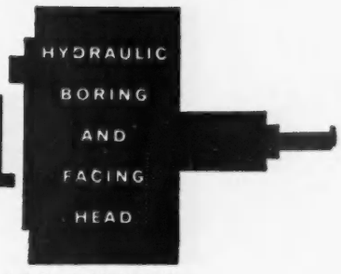

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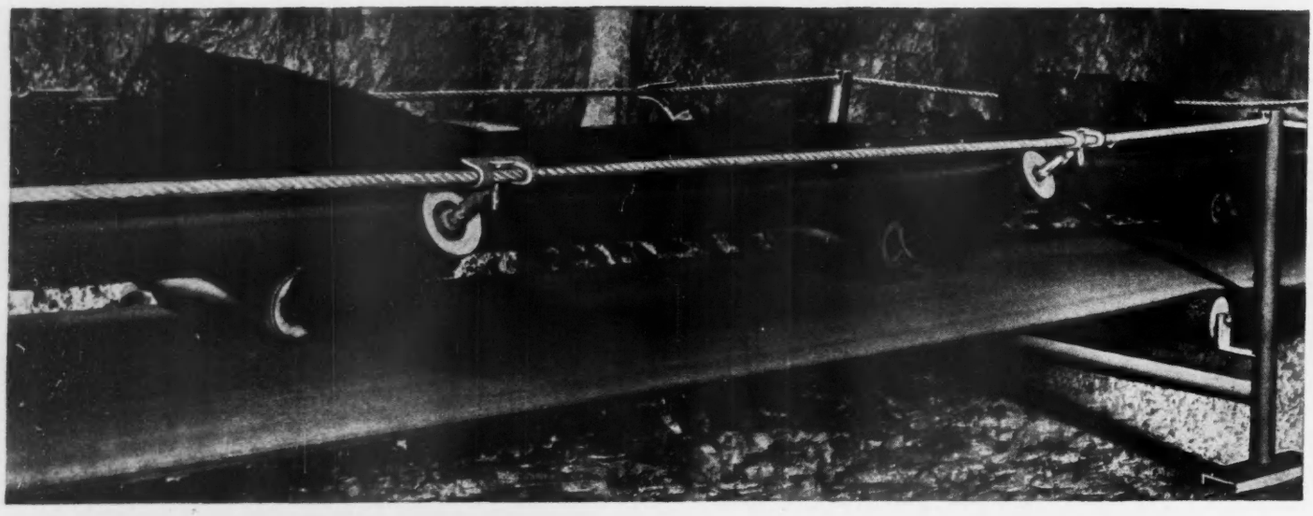
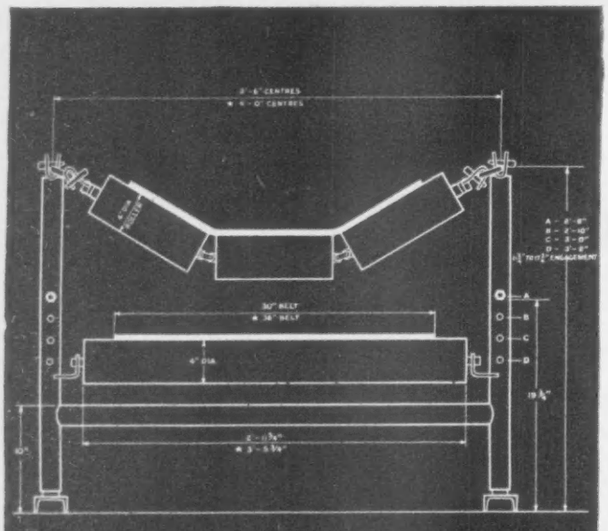
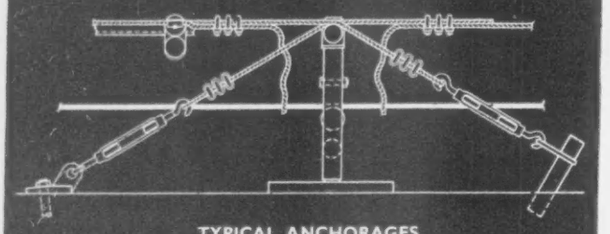




INTERMEDIATE STAND
(Adjustable for height)



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NEW RESILIENT

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BELT CONVEYOR STRUCTURE

(Patented)

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CONVENTIONAL STRUCTURE

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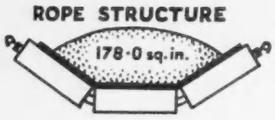

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The longitudinal members of this conveyor structure consist of ⅝" dia. steel ropes in tension. The connections at the ends of each troughing idler shaft are hinged. These basic features provide a resilient conveyor which is easy to stack, transport and install — a conveyor in which impact damage to the belt as it passes over the idlers is greatly reduced. The belt is easy to train. The bottom belt is in full view and there need not be any concealed rubbing between belt and structure.

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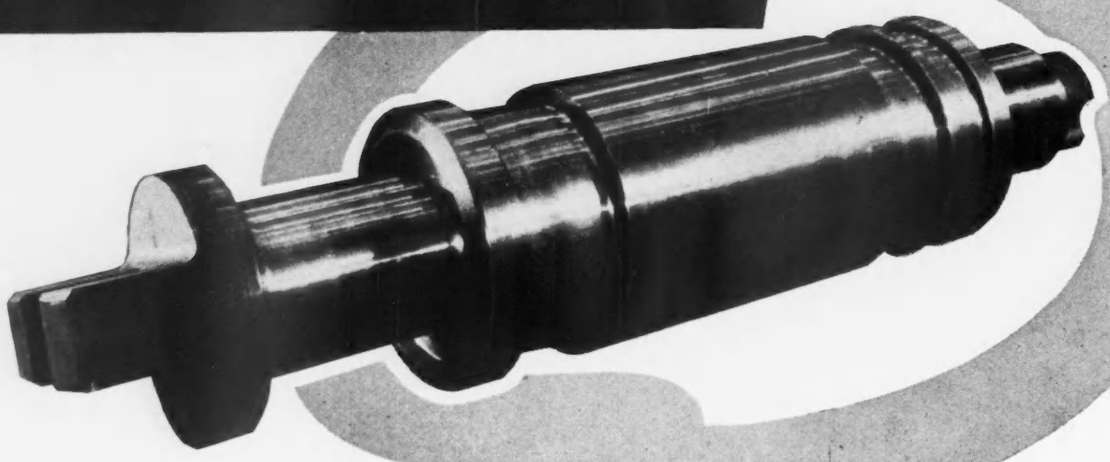

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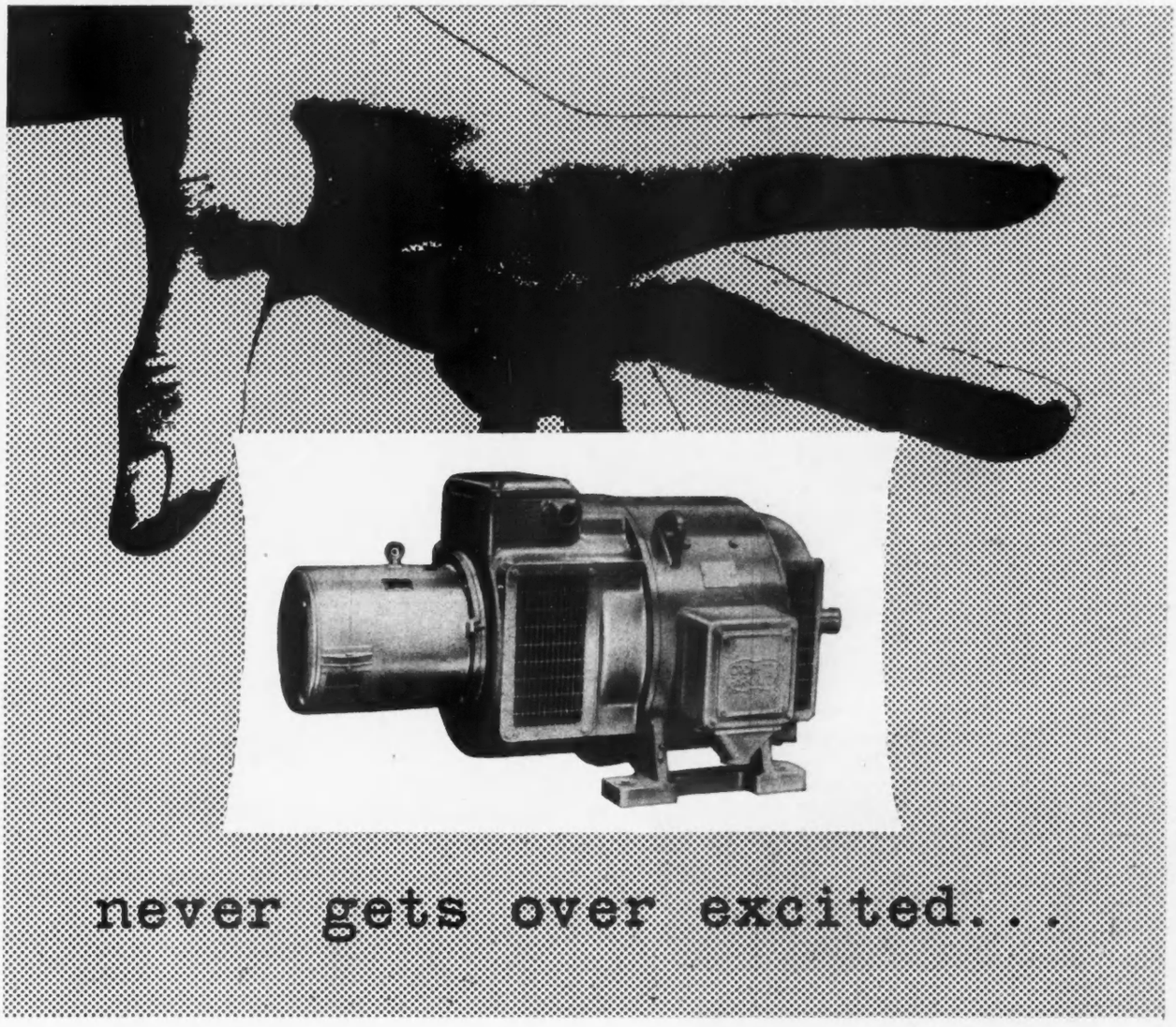

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. . . or for that matter under-excited. These self-regulating alternators with 'Magnicon' excitation automatically hold their output voltage within very close limits from full-load to no-load. Requiring no external voltage regulating gear, they cost less, installed, than a standard alternator. Since the excitation is varied by what is essentially a magnetic amplifier, the 'control box' has neither moving parts nor contacts: it is robust and inherently reliable. Crompton Parkinson self-regulating alternators are based on conventional machines, but with 'Magnicon' excitation. This is one reason for their success. It has made it a relatively simple matter to extend the range so that self-regulating alternators are now available with outputs of 300 kVA. Most important of all, it means that one can be certain of their reliability in advance: the standard alternators have already established that beyond doubt, in all parts of the world under every kind of climatic difficulty.

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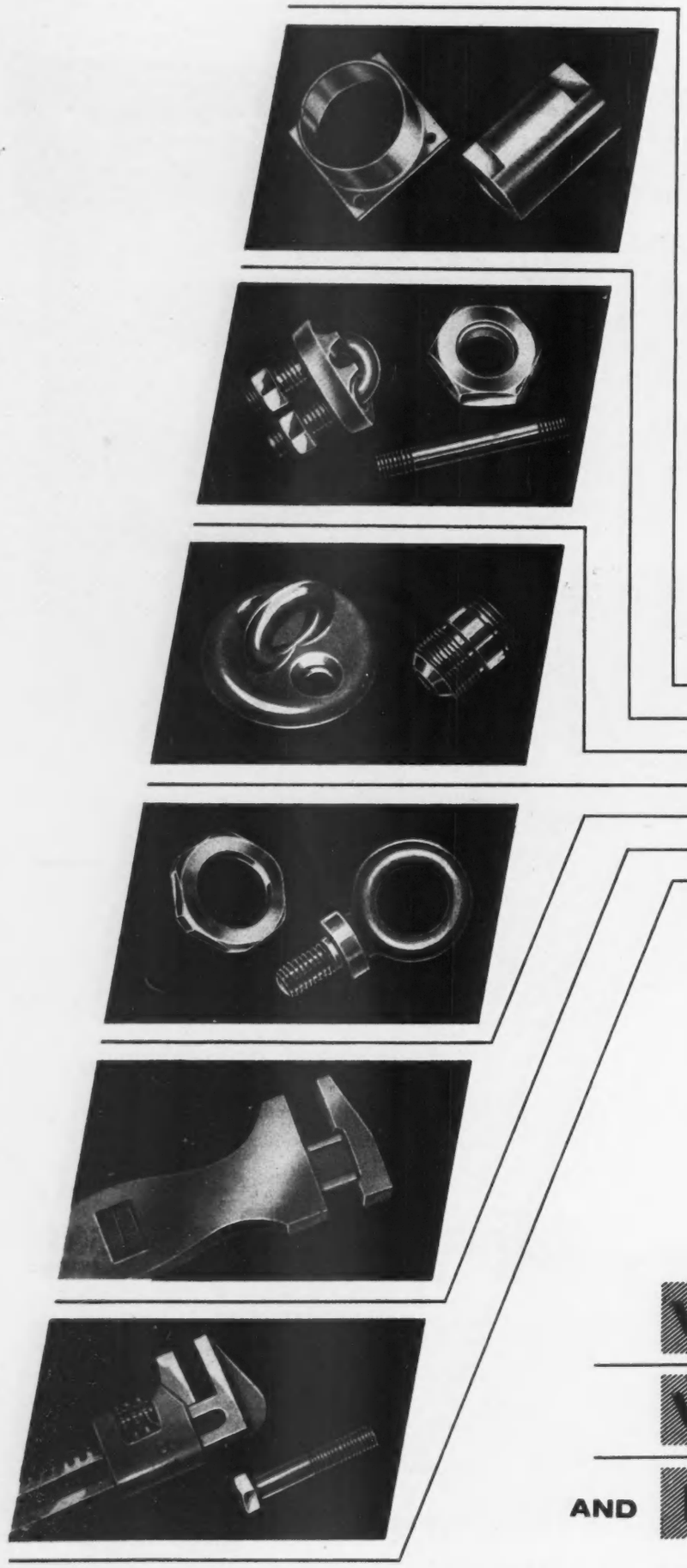

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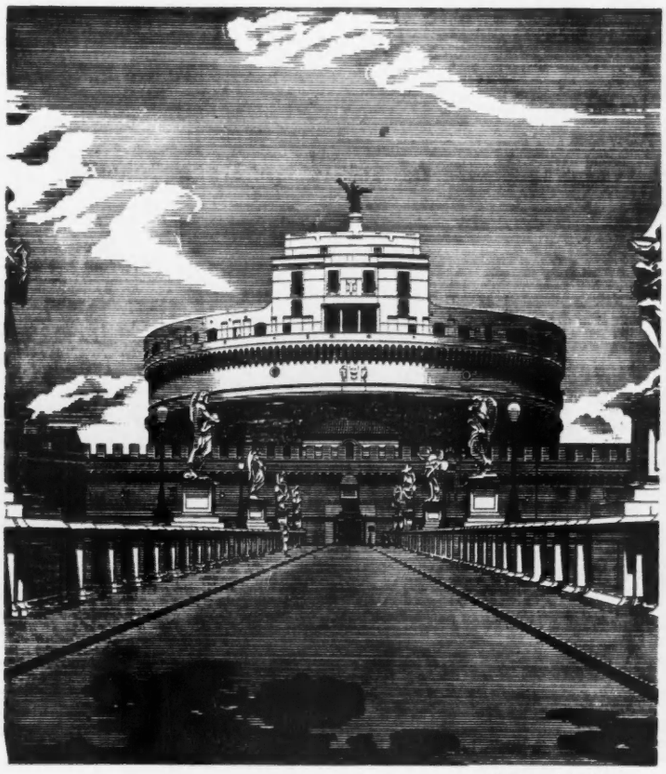

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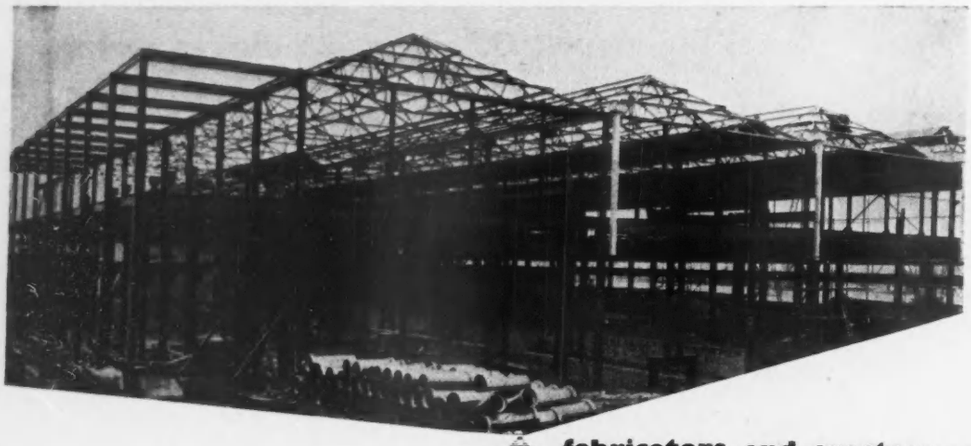

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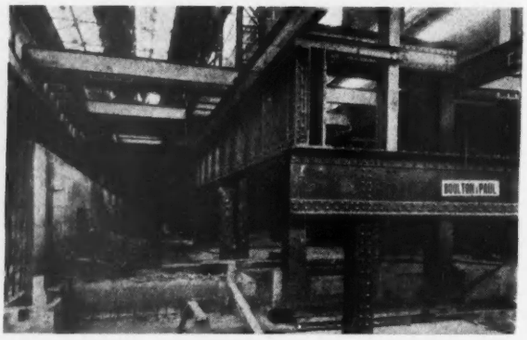
Close-up of the press pit steelwork



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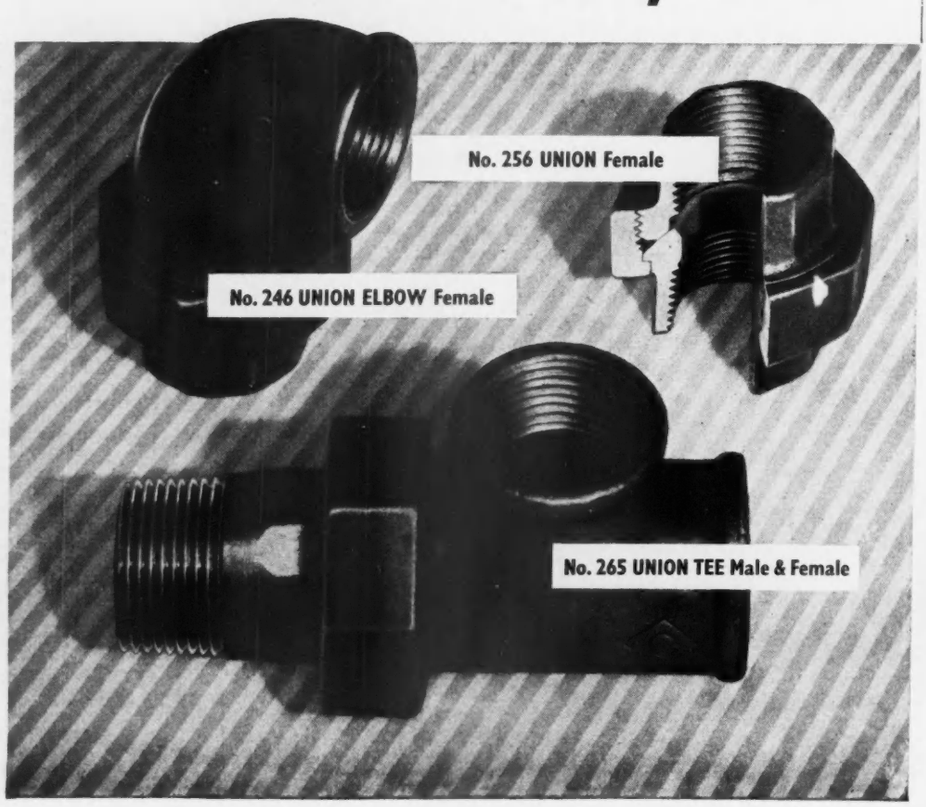

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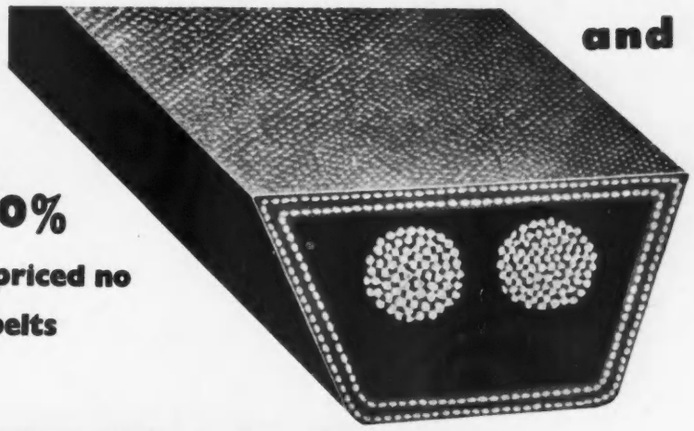

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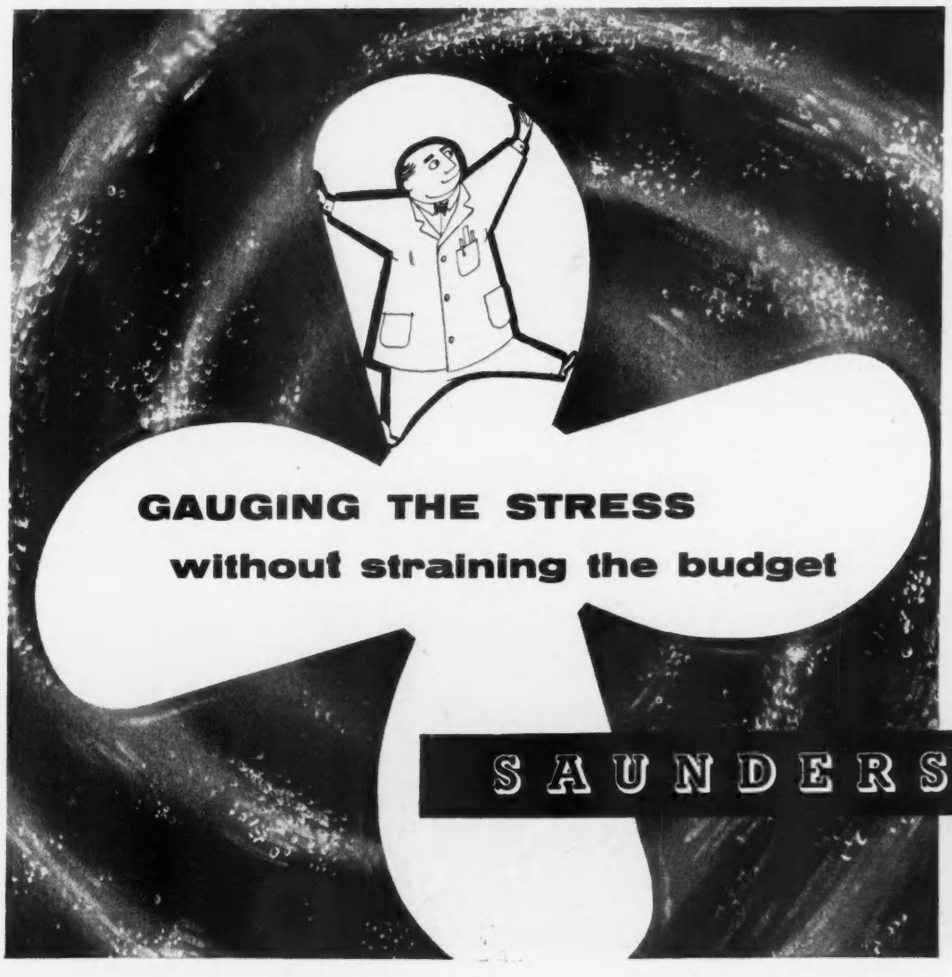

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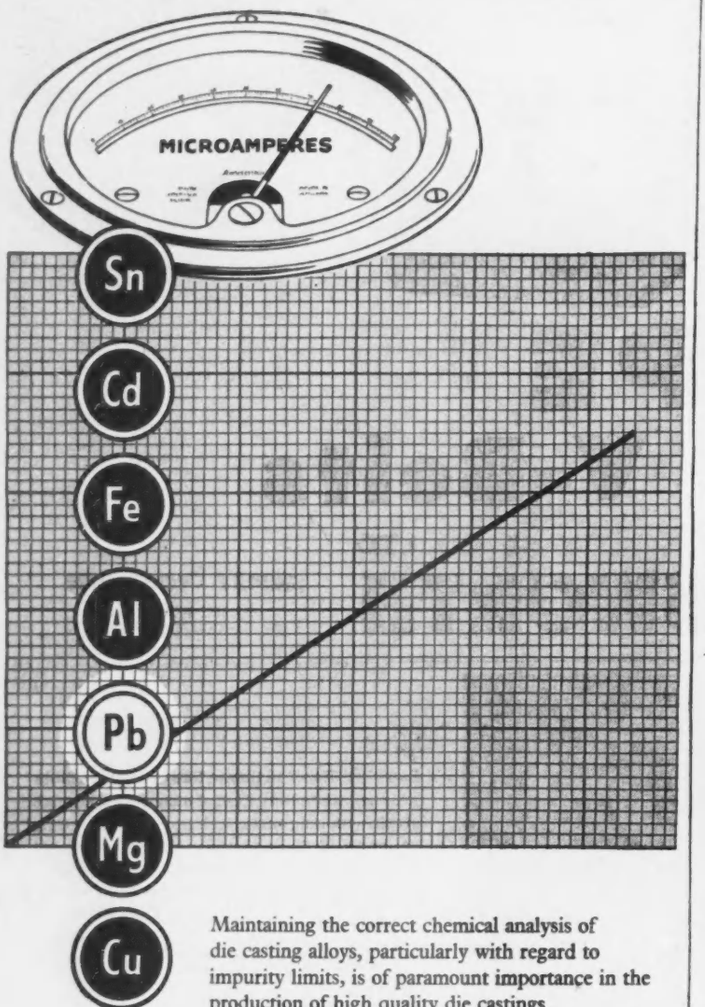

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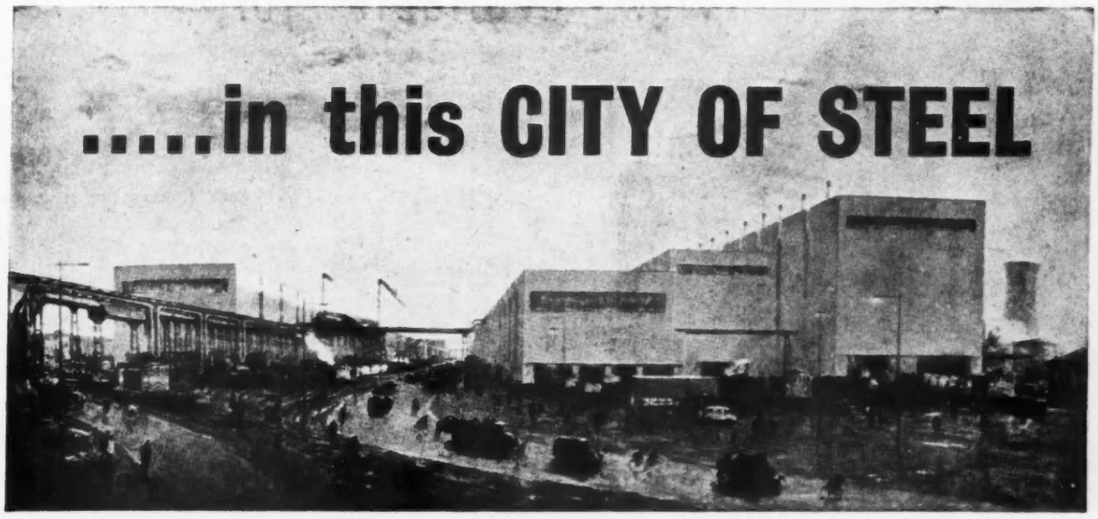

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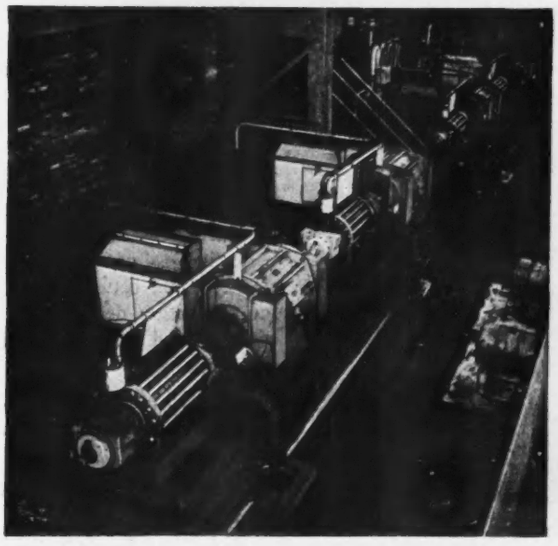

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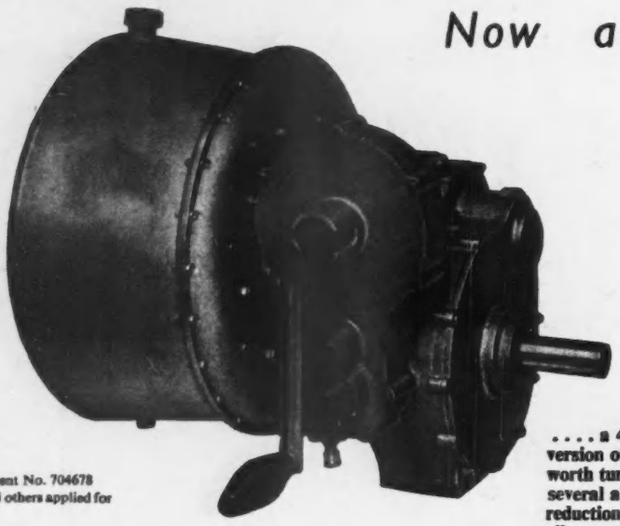

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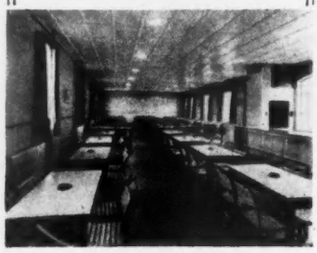
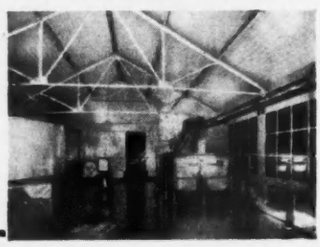
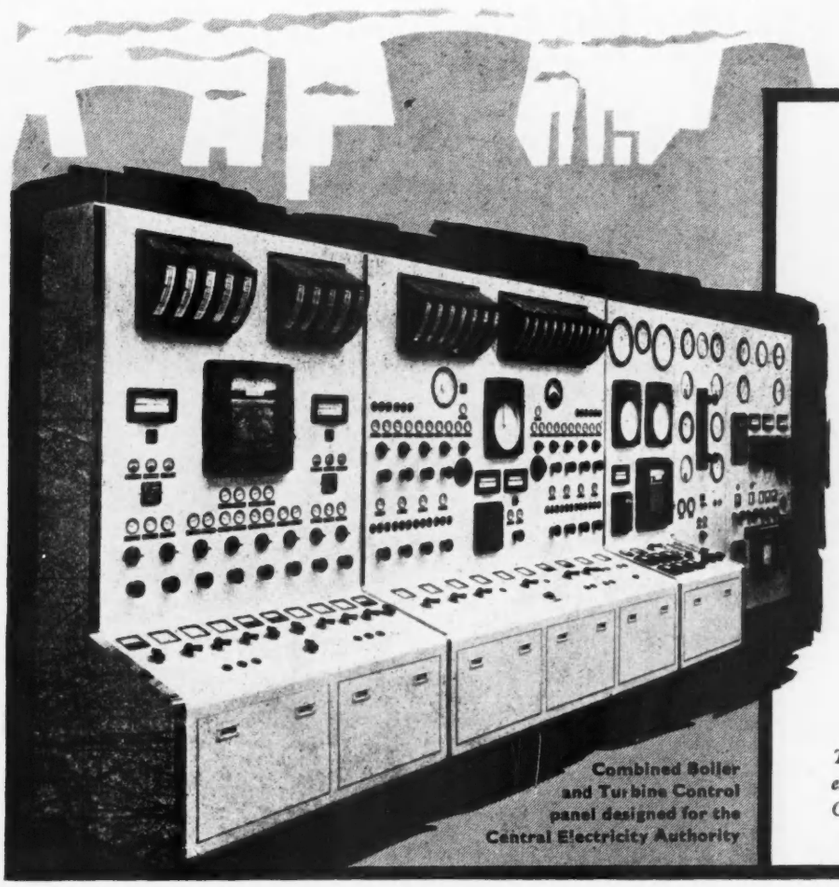


A Permoglazed Canteen.

Dairy Cooling Room treated with Permoglaze





Combined Boiler and Turbine Control panel designed for the Central Electricity Authority

EA

Among the raw materials of industry, fuel is one of the most important. You get the most from fuel with EA equipment and the added advantage that the *complete* installation can be provided from a single source—**The Elliott Automation Group.**

Elliott Brothers (London) Ltd.,
Century Works, Lewisham, London, S.E.13.

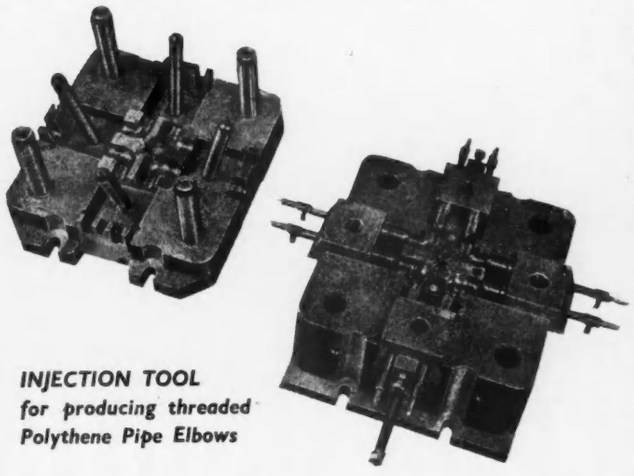
James Gordon and Co., Ltd.,
Dalston Gardens, Stanmore, Middlesex.

Panellit Ltd.,
Dudden Hill Lane, London, N.W.10.

Sauter Controls Ltd.,
Dudden Hill Lane, London, N.W.10.

These member companies of the EA group will be exhibiting at the Industrial Fuel Efficiency Exhibition, Olympia, Stand No. E4.

Moulding Tools by Specialists



INJECTION TOOL for producing threaded Polythene Pipe Elbows

H. B. SALE LTD

PROGRESS WORKS, SUMMER LANE, BIRMINGHAM

Telephone : CEN 5661/3 Grams : SALE, BIRMINGHAM

Established 1862

Budenberg

We now have good stocks of
PRESSURE GAUGES
2½", 3", 4" and 6" dials in all standard ranges.

BUDENBERG GAUGE CO. LTD.,
BROADHEATH Nr. MANCHESTER

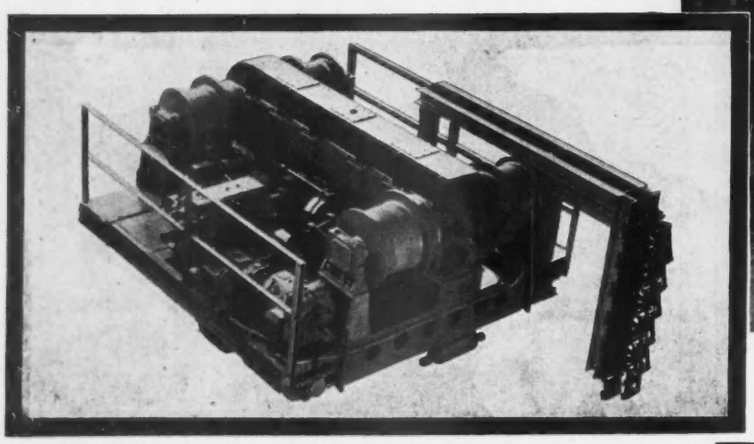
London: REGENCY HOUSE, 1/4 WARWICK STREET, LONDON W.1
Tel: GERrard 4822/3 Grams: Pyrometer, Piccy, London
Glasgow: 62 ROBERTSON STREET, GLASGOW C.2

dmBU37

CLYDE-BOOTH

CONTINUOUS PROCESS CRANES FOR STEELWORKS ETC.

(ABOVE) Clyde-Booth four point suspension electric overhead travelling magnet crane at Messrs. Colvilles Ltd., Ravenscraig Works.
(RIGHT) The hook with slip-ring gear for the magnet, showing attachment of the four ropes.
(BELOW) The special four barrel crab.



With the introduction of higher rates of acceleraton and braking on traversing and long travel motions, in order to get the maximum output from overhead travelling cranes, magnet cranes with multiple splayed ropes are finding favour.

This type of suspension effectively damps out swinging of the load due to acceleration and braking forces.

Clyde-Booth cranes of three and four rope suspension design are produced to meet these requirements.

Our publication "The Booth Handbook on Overhead Cranes" is available on request.

MANUFACTURERS OF

OVERHEAD TRAVELLING CRANES
TRANSPORTER CRANES DOCKSIDE CRANES
DIESEL RAIL CRANES SHIPS DECK CRANES ETC.

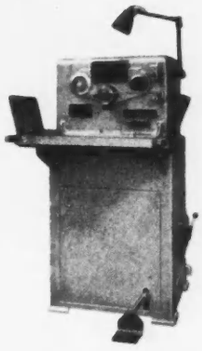
CLYDE BOOTH

CLYDE CRANE & BOOTH LTD.
Incorporating:

Joseph Booth & Bros.,
Union Crane Works, RODLEY, Leeds.
Telephone: Pudsey 3168 (6 lines). Telegrams: "Cranes," Rodley.

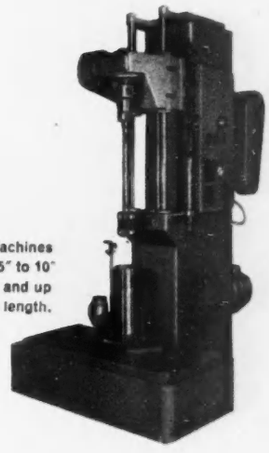
Clyde Crane & Engineering Co.,
MOSSEND, Lanarkshire
Telephone: Holytown 412 (6 lines). Telegrams: "Clyde," Motherwell.

When honing is called for...
ring Cheltenham 56341
for advice on the equipment you need



Horizontal Honing Machines for bores from ·120″ to ·3125″ internal diameter and up to 12″ in length.

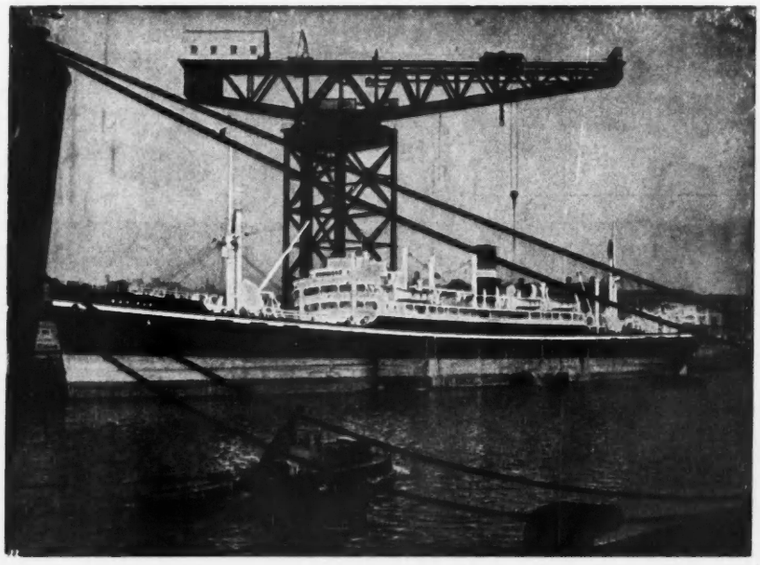
Vertical Honing Machines for bores from ·375″ to 10″ internal diameter and up to 36″ in length.



Automatic correction of taper, ovality and errors of surface finish, elimination of loss on scrap components and consistent accuracy of finish—these are only a few of the advantages that Delapena equipment offers. Give us a ring and we'll tell you anything you want to know, and give you the benefit of some sound advice on honing applied to YOUR particular needs. It will pay you to ask us about honing—we are the experts!

Delapena *precision honing machines & equipment*

DELAPENA & SON LIMITED
Manufacturers of Induction Heating and Precision Honing Equipment
ZONA WORKS · CHELTENHAM · ENGLAND
Telephone: CHELTENHAM 56341



Facilities of
the first class for
Ships and Cargoes—
Foreign and Coastwise

Direct Shipments to and from

The **PORT OF GLASGOW**

on the River Clyde, serve at attractive charges
INDUSTRIAL SCOTLAND
and adjoining territory.

Write General Manager and Secretary
THE CLYDE NAVIGATION TRUST · 16 ROBERTSON ST., GLASGOW C.2
TELEPHONE—CENTRAL 2695

BRIGHT STEEL

ROUNDS · HEXAGONS

SQUARES · FLATS & SECTIONS

THE HALESOWEN STEEL Co., LTD

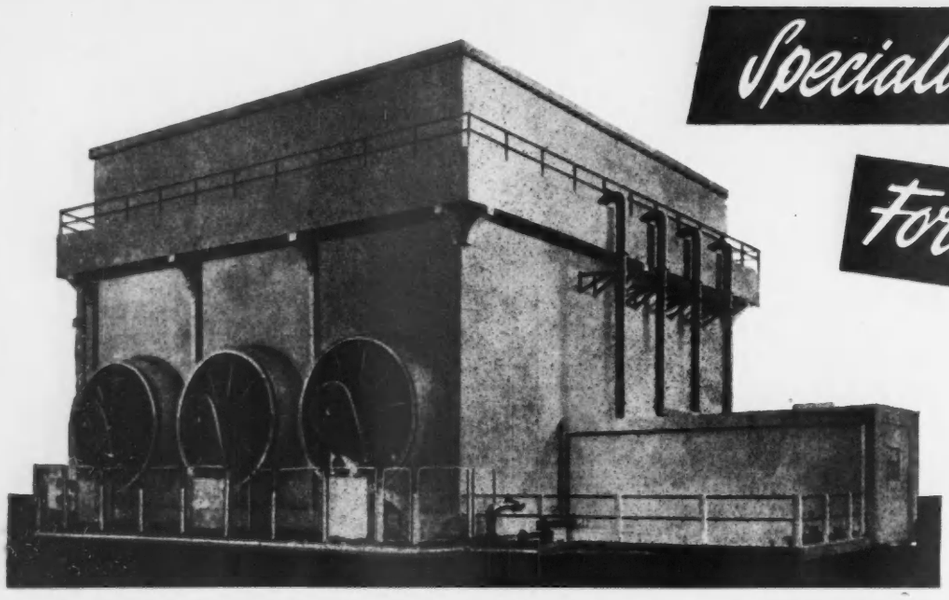
HALESOWEN
Nr. BIRMINGHAM
HALESOWEN 1191

68 VICTORIA ST.
LONDON, S.W.1. VIC: 6992
8 CHATHAM ST.
MANCHESTER, 1. CEN: 0413

CASCADE WATER COOLERS

Specialized Cooling...

Forced Draught



We are fully equipped to carry out promptly the erection of Cooling Towers. Our representative will call upon you at any time.

INQUIRIES INVITED.

CASCADE WATER COOLERS LTD., BREWERY LANE, DEWSBURY

Telephone: Dewsbury 173

LOW-TENSION A.C. AIR BREAK SWITCHGEAR

by

"One of thirty-six composite Switchboards which are being installed in the South of Scotland Electricity Board's Generating Station at Kincardine."

AIR-CIRCUIT BREAKERS, COPPER CONNECTIONS, AND BUS BARS TESTED IN ACCORDANCE WITH A.S.T.A. 16.

CONSULTING ENGINEERS - MESSRS. KENNEDY & DONKIN

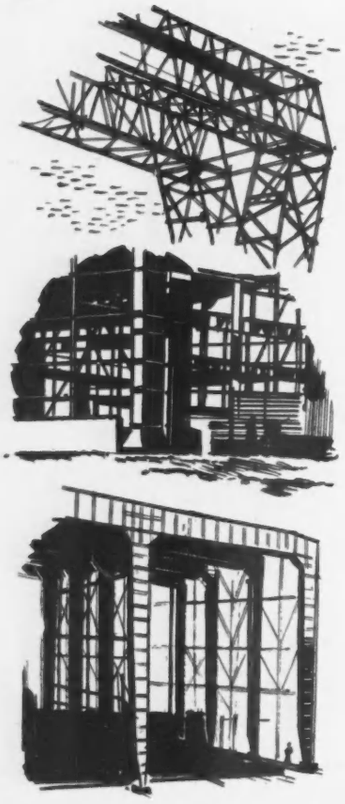
FOR BOOKLET IF/2 WRITE TO

Manufacturers of Air Break Switchgear for the past fifty years.

Whipp & Bourne Ltd

SWITCHGEAR WORKS CASTLETON · ROCHDALE · LANCS

taking the stress



Let FERRANTI take the stress on PEGASUS at the LONDON COMPUTER CENTRE

The calculation of the forces, moments and displacements in structural frameworks is one of the many tasks performed in the Ferranti Computing Service.

You have the problem
We do the work
You get the answers

FERRANTI

For further details of this stressing calculation or the Ferranti Computing Service phone or write :-

FERRANTI LTD · WEST GORTON · MANCHESTER 12 · Tel: EASt 1301
LONDON COMPUTER CENTRE · 21 PORTLAND PLACE, W.1 · Tel: LANgham 9211

DC 66

CLASSIFIED ADVERTISEMENTS

AGENCIES · DIRECTORS · PARTNERSHIPS · SITUATIONS VACANT · EDUCATIONAL PATENTS · BUSINESS OPPORTUNITIES · MISCELLANEOUS · PUBLIC APPOINTMENTS BUSINESSES and PREMISES · TENDERS

Lineage Rate. 4/- per line of approximately 6 words. Minimum 16/-.

Inch Rate. 48/- per single column inch and *pro rata*. 12 lines to 1 inch.

There are reduced rates (*i.e.*, not on a *pro rata* basis) for advertisements of ¼-page (12 column inches) and upwards, e.g., ¼-page £25 10s. ½-page £48. Full page £90.

AUCTION SALES · FOR HIRE · MACHINERY, etc., WANTED · SITUATIONS WANTED DRAWING AND DESIGN SERVICES · FOR SALE · SUB-CONTRACTING

Lineage Rate. 3/6 per line of approximately 6 words. Minimum 14/-.

Inch Rate. 42/- per single column inch and *pro rata*. 12 lines to 1 inch.

There are reduced rates (*i.e.*, not on a *pro rata* basis) for advertisements of ¼-page (12 column inches) and upwards, e.g., ¼-page £22. ½-page £41 10s. Full page £78.

Series Discounts. For advertisements 1 inch and upwards. 6 insertions 5%. 13 insertions 10%. 26 insertions 15%.

Run-on and Semi-Displayed Styles. Both these styles are available for single column width advertisements of any depth up to 12 inches.

Displayed and Illustrated Styles. The minimum size for a Displayed advertisement is 3 inches single column, for an illustrated advertisement it is a ¼-page (12 column inches). Thereafter the sizes for both progress in steps 3 inches deep across 1, 2, 3 or 4 columns.

Use of Box Number. 2/- which includes forwarding of replies.

Copy Dates. "Run-on" and "Semi-displayed" advertisements by noon Tuesday for publication on Friday same week. "Displayed" and "Illustrated" advertisements by noon Friday for publication on following Friday. All advertisements three days earlier if proofs are required.

***Advertisements for publication should be addressed to:*—Classified Advertisement Dept., "The Engineer", 28 Essex Street, Strand, London, W.C.2.**

Urgent advertisements may be telephoned to CENtral 6565.

PUBLIC APPOINTMENTS

ROYAL TECHNICAL COLLEGE

SALFORD

LECTURER OR SENIOR LECTURER

Required, LECTURER or SENIOR LECTURER IN MACHINE TOOL TECHNOLOGY in the Department of Mechanical Engineering. Candidates should have an Honours Degree in Engineering or Applied Science (or equivalent), and should have had research or design experience connected with machine tools or other relevant special knowledge or experience. Full-time or part-time teaching experience would be an advantage. The successful candidate will be expected to teach up to Diploma in Technology Standard, and will be responsible to the Head of Department for the development of teaching and research laboratories in this field. A new machine tool laboratory is at present being equipped for teaching and for the present research programme; further considerable extensions are planned to both the laboratory and the equipment to enable research and development in this field to be accelerated. Existing facilities are considerable and will give ample opportunity for immediate development in this field. Laboratory assistance and research demonstratorships are available for research work in machine tools. There is an excellent Metrology Laboratory in the Department.

Salary in accordance with the Burnham Technical Scale:

Lecturers: £1200 by £30 to £1350 (men), £960 by £24 to £1080 (women) (plus four-sevenths differential).

Senior Lecturers: £1350 by £50 to £1550 (men), £1080 by £40 to £1240 (women) (plus four-sevenths differential).

Increments up to the maximum can be given for appropriate industrial, teaching, research or professional experience.

Further particulars and forms of application may be obtained from the Principal, Royal Technical College, Salford, 5, to whom completed forms should be returned as soon as possible.

R. RIBBLESDALE THORNTON,
Clerk to the Governors.

E8650

BRIGHTON EDUCATION COMMITTEE

BRIGHTON TECHNICAL COLLEGE

Principal: G. E. WATTS, M.A., Ph.D. (Cantab), B.Sc. (Lond.), F.R.I.C.

LECTURERS

Required, (a) LECTURER IN HYDRAULICS, to teach subject to Degree and professional levels. Degree in Engineering required. Corporate Membership of Institution of Civil Engineers an advantage.

(b) ASSISTANT LECTURER (GRADE B) IN MECHANICAL ENGINEERING. Graduate, A.M.I.Mech.E., or equivalent.

Teaching and industrial or research experience desirable.

Salary scales: (a) £1200 by £30 to £1350; (b) £650 by £25 to £1025, plus graduate and training allowances.

Increments for approved industrial, professional or research experience.

Further particulars and forms of application from the undersigned, to be returned to the Principal, Brighton Technical College, Brighton, 7, as soon as possible.

W. G. STONE,
Director of Education.

54, Old Steine,
Brighton.

E8653

UNIVERSITY OF SHEFFIELD

POSTGRADUATE DEPARTMENT OF APPLIED MECHANICS

LECTURER

Applications are invited for a post of LECTURER in the Postgraduate Department of Applied Mechanics to begin duties on 1st January, 1959. Salary scale £900 by £50 to £1350 by £75 to £1650, with F.S.S.U. provision and family allowance. Initial salary according to qualifications and experience.—Further particulars should be obtained from the Registrar to whom applications (4 copies) should be sent by 18th October, 1958.

E8641

PUBLIC APPOINTMENTS

CITY AND COUNTY OF NEWCASTLE UPON TYNE EDUCATION COMMITTEE

RUTHERFORD COLLEGE OF TECHNOLOGY

(SELECTED FOR DEVELOPMENT INTO A COLLEGE OF ADVANCED TECHNOLOGY)

APPOINTMENTS

Applications are invited for the following posts:—

(i) HEAD OF DEPARTMENT OF MECHANICAL AND CIVIL ENGINEERING (Grade V).—Salary: £1900 by £50 to £2050. Applicants, who should be mechanical engineers, should have a good or higher university Degree, be professionally qualified and have had good industrial research and, preferably, teaching experience.

(ii) SENIOR LECTURER IN MECHANICAL ENGINEERING, for work in connection with Higher National Certificate, Higher National Diploma, Dip. Tech. and Degree courses. Applicants should hold a good Honours or higher Degree, be Corporate Members of a professional Institution, have had good industrial and/or research and, preferably, teaching experience; and be able to offer two or more of the following: Applied Thermodynamics and Heat Transfer, Theory of Machines, Mechanics of Fluids and Hydraulics, Machine Design.

(iii) LECTURER IN CIVIL ENGINEERING for Higher National Certificate and Higher National Diploma courses, including Structural Engineering. Applicants should hold a good Degree in Civil Engineering, have had at least 3 years' experience in the design and construction of civil engineering works and, preferably, some teaching experience.

(iv) LECTURER IN METALLURGY, capable of teaching up to L.I.M. standard in Mechanical and Thermal Treatment and in Production of Iron and Steel. Applicants should be graduates with practical experience, preferably in the steel-making industry, and have spent some time in teaching.

Salary Scales: Senior Lecturer, £1350 by £50 to £1550. Lecturer, £1200 by £30 to £1350.

Application forms (returnable within fourteen days) and further particulars may be obtained from the Principal, Rutherford College of Technology, Bath Lane, Newcastle upon Tyne, 1.

H. V. LIGHTFOOT,
Clerk to the Governors.

E8668

SURREY EDUCATION COMMITTEE

WIMBLEDON TECHNICAL COLLEGE
GLADSTONE ROAD, S.W.19

LECTURER

LECTURER required in January, 1959, to teach Mechanical Engineering subjects to Higher National Certificate level, with particular reference to Mathematics. Applicants should be graduates with suitable teaching and industrial experience. Salary: Burnham Scale, £1200 by £30 to £1350, plus London Allowance.

Application form and further particulars may be obtained from the Principal. Applications required within two weeks of date of advertisement.

E8673

WILTSHIRE EDUCATION COMMITTEE

NORTH WEST WILTSHIRE AREA COLLEGE OF FURTHER EDUCATION

LECTURER

Required, as soon as possible, LECTURER (salary, £1200–£1350), to teach and be responsible for, Mechanical Engineering subjects up to H.N.C., Engineering Drawing will also be required. Candidates should be graduates or possess equivalent qualifications and should have had good teaching and industrial experience. Required for 1st January, 1959, ASSISTANT TEACHER, Grade B, to teach Workshop Practice, Workshop Technology, &c., up to Final City and Guilds.

Application forms and further particulars may be obtained from the Principal, Cocklebury Road, Chippenham.

17th September, 1958.

E8664

PUBLIC APPOINTMENTS

UNIVERSITY OF CAPE TOWN

SOUTH AFRICA

LECTURER IN MECHANICAL ENGINEERING

Applications are invited for the LECTURESHIP in the Department of Mechanical Engineering.

The salary scale is £850 by £50 to £1200 per annum. There is also a temporary cost-of-living allowance for a married man (at present £234 per annum).

Applications (with copies of testimonials) should state age, qualifications, experience and research work completed or in progress and give the names of two referees whom the University may consult.

Two copies of the application and testimonials should reach the Secretary, Association of Universities of the British Commonwealth, 36, Gordon Square, London, W.C.1 (from whom memoranda giving the general conditions of appointment and further information about the work of the Department of Mechanical Engineering should be obtained), not later than 31st October, 1958. An additional copy should be sent direct by air mail to the Registrar, University of Cape Town, Private Bag, Rondebosch, Cape Town, South Africa, by the same date.

The University reserves the right to appoint a person other than one of the applicants or to make no appointment.

E8663

COLLEGE OF AERONAUTICS

CRANFIELD, BLETCHLEY, BUCKS

LECTURER AND DEMONSTRATORS

LECTURER and DEMONSTRATORS required in METALLURGY or the MATERIALS SCIENCES, to teach at post-graduate level in specialised fields. There is a particular requirement for Specialists in Non-Metallic Materials or in Metal Technology, but other branches are relevant. Good facilities exist for research and publication is encouraged. Demonstrators must be academically qualified and will, if suitable, be considered for subsequent promotion to Lecturer. A housing scheme is in operation at the College. Salary within scales: Lecturer, £900 by £50 to £1350 by £75 to £1650. Demonstrators: £650 by £25 to £1000, with F.S.S.U. and family allowances.

Applications, including names of three referees, to Recorder, The College of Aeronautics, Cranfield, Bletchley, Bucks. Further particulars available.

E8680

HAMMERSMITH COLLEGE OF ART AND BUILDING

HEAD OF DEPARTMENT OF BUILDING, STRUCTURAL ENGINEERING AND SURVEYING

Applications invited for appointment as HEAD OF DEPARTMENT OF BUILDING, STRUCTURAL ENGINEERING AND SURVEYING.

Candidates should hold an appropriate recognised qualification of Graduate status and have preferably both teaching and industrial or professional experience.

Salary scale: £1600 by £25 to £1750, plus London Allowance of £36 or £48, according to age.

Application forms from the Secretary, Lime Grove, London, W.12, to be returned by 10th October, 1958. (1777)

E8681

UNIVERSITY OF NOTTINGHAM

DEPARTMENT OF MECHANICAL ENGINEERING

SENIOR RESEARCH ASSISTANT

Honours graduates in Engineering or Physics are invited to apply for appointment as SENIOR RESEARCH ASSISTANT in the above Department for work on fatigue of metals or experiments in stress analysis. Candidates may read for Higher Degrees. Lecturers' salary scale £900 by £10 to £1300 with membership of Universities Superannuation Scheme and family allowances. Conditions of Appointment and Form of Application, which should be returned by Saturday, 18th October, from The Registrar.

E8690

PUBLIC APPOINTMENTS

NOTTINGHAMSHIRE EDUCATION COMMITTEE

WEST NOTTINGHAMSHIRE DIVISIONAL EXECUTIVE

MANSFIELD TECHNICAL COLLEGE

Principal: R. F. BEATON, B.Sc. (Eng.), Wh.Sch.

APPOINTMENTS

Applications are invited for the following appointments in the Engineering Department.

1. LECTURER

The teaching duties will be in the Advanced courses in Mechanical Engineering applied to Mining and associated courses. Applicants should possess Graduate or equivalent qualifications and should have had suitable industrial and teaching experience.

2. GRADE B

The main teaching duties will be in the Craft courses up to City and Guilds Final level for the Engineering and Mining Industries. Candidates should hold suitable qualifications and have had some industrial and/or teaching experience.

3. GRADE A

The teaching duties will be mainly in the preliminary Engineering courses and the lower levels of the Craft and Ordinary National Certificate courses. Candidates should offer several of the following subjects:—Mathematics, Science, Engineering Drawing and English. Applicants should be suitably qualified and preferably have had some industrial and/or teaching experience.

Salaries are in accordance with the Burnham Scale for Teachers in Further Education Institutions.

Forms of application (S.A.E.) obtainable from the Divisional Education Officer, Education Office, Mansfield, should be completed and returned to him without delay.

J. EDWARD MASON,
Director of Education.

County Hall,
Nottingham.

E8691

UNIVERSITY OF SOUTHAMPTON

VOKES RESEARCH SCHOLARSHIP

Applications are invited for the VOKES RESEARCH FELLOWSHIP, tenable in the Department of Mechanical Engineering. The Fellow will be expected to undertake research in the field of filtration, the separation of mixtures, or allied problems in fluid mechanics. Salary, £900 per annum. Tenure two or three years.

Further particulars from Secretary and Registrar, The University, Southampton, to whom applications (6 copies) should be sent not later than 18th October, 1958.

E8688

TANGA TOWN COUNCIL

APPOINTMENT OF TOWN ENGINEER

It is possible that the above post will fall vacant in the near future.

Applications are accordingly invited for the post of TOWN ENGINEER, Tanga.

Applicants should be Associate Members of the Institution of Civil Engineers, or hold an equivalent qualification, and should have at least five years' practical experience with a large civil engineering firm or a Local Authority.

The salary will be within the scale £1600 per annum, rising by annual increments of £45 per annum to £2005 per annum.

The appointment will be subject to the Council's Conditions of Service, which include tours of 36 months, overseas passages, provident fund, housing and medical benefits.

Applications, with the names of at least three referees, should reach the undersigned not later than 18th October, 1958.

Applicants must disclose whether or not they are related to any member of the Tanga Town Council.

JOHN F. W. SIMS,
Town Clerk.

Town Hall,
P.O. Box 58,
Tanga, Tanganyika.
6th September, 1958.

E8684

Classified Advts. continued on page 116

PUBLIC APPOINTMENTS

GOVERNMENT OF WESTERN NIGERIA

MINISTRY OF WORKS AND TRANSPORT

MECHANICAL ENGINEERS

To assist in the operation and supervise the maintenance in the field, of road vehicles, heavy earth-moving equipment, and all types of building, water works and civil engineering contractors' plant, and/or to take charge of workshops undertaking the repair and complete overhaul of this equipment and possibly to take full charge of the installation of, or carry out acceptance tests on, fixed plant.

Contract appointment. Salary range £1410 to £2082 p.a. Gratuity of £37 10s. for each completed three months' service payable on satisfactory completion of contract. Free passages for officer and wife, and cost of passages for children under 18 to a maximum of £450. Quarters at low rent. Free medical attendance.

Candidates, between 25 and 50, must have passed or be exempt from Parts I and II of the Institution of Mechanical Engineers examination with at least 3 years' practical experience after completing their pupilage or apprenticeship, be holders of a current driving licence and have a good knowledge of general engineering practice and the overhaul of both petrol and diesel-engined road vehicles, together with experience of modern workshop practice and costing. A knowledge of stores procedure and sealing would be an advantage.

Write, Director of Recruitment, Colonial Office, London, S.W.1, stating briefly age, qualifications and experience, quoting BCD 112/410/023(B). E8692

MANCHESTER CORPORATION WATERWORKS

ASSISTANT ENGINEERS

Applications are invited for the undermentioned appointments in connection with the design and construction of treatment and filtration plant, and large service reservoirs, the reconstruction of existing reservoirs, and the reconditioning of main aqueduct :

ASSISTANT ENGINEERS (Class II)—£750–£1030.

ASSISTANT ENGINEERS (Class III)—£575–£845.

Applications stating (1) age, (2) education and training, (3) professional qualifications, (4) experience in the preparation of plans and construction of waterworks or other civil engineering works, together with the names of two referees, should be addressed to the Engineer and Manager, Waterworks Offices, Town Hall, Manchester, 2, not later than 6th October, 1958. E8624

COUNTY BOROUGH OF BOLTON

WATERWORKS DEPARTMENT

ENGINEERING ASSISTANT

Applications invited for appointment of ENGINEERING ASSISTANT, Grade A.P.T. IV (£1025–£1175). Candidates must be Chartered Engineers (Civil or Mechanical) and have experience in the design, construction or operation of waterworks plant or structures. The appointment is superannuable subject to medical examination. House available if required.

Applications giving details of age, training, qualifications and experience and naming three referees, must be received by me not later than 6th October.

PHILIP S. RENNISON,
Town Clerk

E8626

COUNTY BOROUGH OF EAST HAM

ASSISTANT ENGINEER (MECHANICAL) GRADE III

£845–£1025

London Weighting is paid in addition. Salary in excess of the minimum may be paid, according to qualifications and experience.

A subsistence allowance may be granted over a reasonable period to the person appointed if unable to obtain suitable housing accommodation, necessitating the maintenance of two homes.

Further details and application forms, returnable by 10th October, 1958, from the Town Clerk, Town Hall, E.6. E8662

PUBLIC APPOINTMENTS

ESSEX RIVER BOARD

TWO CIVIL ENGINEERING ASSISTANTS

Applications are invited for the following permanent posts which are subject to the Local Government Superannuation Acts, 1937 and 1953 :—

TWO CIVIL ENGINEERING ASSISTANTS, A.P.T. IV (£1025–£1175).

Applicants should be Chartered Civil Engineers experienced in coast protection works and/or the design and calculation of river improvement schemes or surface-water sewerage schemes. Experience in the design of pumping stations would be an advantage.

Car allowances on the Essential Users' scale will be payable.

Applications, giving details of age, education and previous experience, and the names of three referees with a knowledge of the applicant's technical experience, should be submitted to the Engineer to the Board at the address given below, not later than the 20th October, 1958.

(Signed) W. J. S. BEW,
Clerk of the Board.

Rivers House,
129, Springfield Road,
Chelmsford,
Essex,
16th September, 1958. E8651

BRITISH RAILWAYS RESEARCH DEPARTMENT

DERBY

SCIENTIFIC OFFICER

Vacancy for SCIENTIFIC OFFICER, Grade I, at Derby, to take charge of project involving original work in soil mechanics. Candidates should preferably have good Honours Degree and have had previous experience of experimental work in this field.

Salary range : £1015 to £1120 per annum.
Certain free and reduced rate travel facilities.
Medical examination.
Applications, stating age, qualifications, &c., to :
Director of Research,
British Transport Commission,
(British Railways Division),
222, Marylebone Road,
London, N.W.1. E8665

NORTH THAMES GAS BOARD

CHIEF ENGINEER'S DEPARTMENT, WESTMINSTER

SENIOR DRAUGHTSMAN

A SENIOR DRAUGHTSMAN is required in the Chief Engineer's Department at Westminster for the layout and design of coal and coke handling and screening plant, together with associated structural steelwork.

Candidates should preferably be Corporate Members of the Institution of Civil, Structural or Mechanical Engineers.

Starting salary within the region of £1000 per annum according to age, qualifications and experience.

The successful candidate will be required to join the staff pension scheme.

Applications, giving age and full particulars, should be sent to the Staff Controller, 30, Kensington Church Street, W.8, quoting reference TE/314. E8661

ATOMIC ENERGY RESEARCH ESTABLISHMENT

HARWELL

ENGINEER

A professional ENGINEER is required to advise on the engineering aspects of nuclear physics research apparatus and to progress it from design to commissioning. An Honours Degree in Engineering would be an advantage.

Salary : £1300–£1740 (Engineer II).

Send a Post Card to the Group Recruitment Officer (1213/25), U.K.A.E.A., A.E.R.E., Harwell, Berks, for details and application form. E8643

ASSISTANT CHIEF INSTRUMENTS ENGINEER

is required by the

UNITED KINGDOM ATOMIC ENERGY AUTHORITY

(Industrial Group Headquarters)

at

RISLEY · WARRINGTON · LANCASHIRE

The successful candidate will be responsible to the Chief Instruments Engineer for the work of a Design Office employing a team of Engineers and Draughtsmen engaged in the design and application of measurement and control systems for the Authority's Industrial Group Projects. These include extensive chemical plants and unique processes for the treatment of radioactive materials as well as prototype and testing reactors.

A recognised engineering apprenticeship, or comparable training, corporate membership of a senior engineering institution, or equivalent, and extensive and varied experience in the field of industrial instrumentation, including supervisory experience as a senior design engineer, are essential. Familiarity with the equipment and techniques employed for radioactivity measurements is desirable and candidates must be capable of understanding and assessing the complex problems encountered in the broad field described above.

Salary within the range **£2,100-£2,600** *according to qualifications and experience.*

There is a contributory pension scheme and housing can be provided, if required.

Write for application form, quoting reference 2617, to Chief Recruitment Officer, at above address.

CLOSING DATE: 6th OCTOBER, 1958

E8640

PUBLIC APPOINTMENTS

COUNTY BOROUGH OF BARNSLEY

WATER DEPARTMENT

ASSISTANT ENGINEER

Applications are invited for appointment as ASSISTANT ENGINEER at a salary in accordance with A.P.T. Division, Grade IV (£1025 per annum by £50 to £1175).

Candidates must be Chartered Civil Engineers, and the commencing salary will be according to experience and qualifications, with special reference to the design, construction and maintenance of waterworks.

The appointment will be subject to (a) the Scheme of Conditions of Service for A.P.T.C. staff ; (b) any other General Conditions of Employment in operation within the Corporation from time to time, and (c) one month's notice on either side.

The appointment will also be subject to the Local Government Superannuation Acts, for which purpose the successful candidate will be required to pass a medical examination.

A car allowance is payable.

Applications, setting out details of general and technical education and subsequent practical experience, and giving the names of two referees, should reach the Waterworks Engineer and Manager, Waterworks Office, Town Hall, Barnsley, not later than the 13th October next.

Canvassing will disqualify.

A. E. GILFILLAN,
Town Clerk.

Town Hall,
Barnsley,
September, 1958. E8693

TENDERS

FLEET URBAN DISTRICT COUNCIL

AVONDALE ROAD SEWAGE PUMPING STATION

CONTRACT NO. 5

TO MANUFACTURERS OF CENTRIFUGAL PUMPING PLANT

TENDERS are invited for TWO SETS OF VARIABLE SPEED ELECTRICALLY DRIVEN AND ONE SET ELECTRICAL/DIESEL-ENGINE DRIVEN VERTICALLY ARRANGED UNCHOKEABLE SEWAGE PUMPS and ancillary equipment. Two of the pumps are to be capable of a duty of 400 gallons per minute against a total head of 71ft., and one pump for a duty of 800 gallons per minute against a total head of 71ft., all in accordance with the specification and drawings prepared by the Engineers, Messrs. John Taylor and Sons, Artillery House, Artillery Row, Victoria Street, Westminster, S.W.1.

Copies of the specification and drawings may be obtained from the engineers upon payment of £5 (cheque only), made payable to the Council, which will be returned upon receipt of a bona-fide Tender. The contract documents may be inspected at the Offices of the engineers.

Tenders, in plain sealed envelopes, endorsed "Tender—Fleet Drainage, Contract No. 5," and addressed to me, are to be delivered at the Council Offices on or before noon on Monday, the 10th November, 1958.

The Council does not bind itself to accept the lowest or any Tender.

(Signed) D. COLLIER,
Clerk of the Council.

Council Offices,
Fleet,
Hants E8683

CITY OF LEEDS

WATERWORKS DEPARTMENT

BRAMLEY RESERVOIR

BOOSTER PUMPING STATION

The Waterworks Committee of the Leeds City Council invites TENDERS for the SUPPLY, ERECTION and MAINTENANCE of an ELECTRICALLY DRIVEN AUTOMATIC BOOSTER PUMPING PLANT, having a capacity of 80 gallons per minute against a total head of 50ft., complete with Switchgear, Motors, Time Controls, Air Pressure Tank, Air Compressor, Piping and Valves.

Plan, specification and forms of Tender and Instructions to Persons Tendering may be obtained upon application to the undersigned.

Forms of Agreement and Conditions of Contract and the Institution of Electrical Engineers' General Conditions of Contract (Home Contracts—With Erection) may be seen at the Waterworks Department, Room 14, Civic Hall, Leeds, 1.

The Waterworks Committee does not bind itself to accept the lowest or any Tender.

Tenders must be enclosed in plain, sealed covers endorsed "Tender for Pumping Plant—Waterworks," and be delivered at the Town Clerk's Office, Room 57, Civic Hall, Leeds, 1, not later than 12 noon on Friday, 31st October, 1958.

KENNETH L. FORSTER, M.I.C.E.,
General Manager and Engineer.

Civic Hall,
Leeds, 1,
22nd September, 1958. E8696

EDUCATIONAL

A.M.I.MECH.E., B.Sc., City and Guilds, &c. Guarantee Postal Courses for all Exams., and Technical Divisions from Elementary to Degree standard. Approximately 95 per cent successes. 144-page prospectus free on request.—B.I.E.T. (Dept. 22), 29, Wright's Lane, London, W.8. E114 B

SITUATIONS VACANT

APPLICANTS ARE ADVISED TO SEND COPIES, NOT ORIGINALS, OF THEIR TESTIMONIALS UNLESS OTHERWISE REQUESTED.

A COMPANY OF BRIDGE AND CONSTRUCTIONAL ENGINEERS of repute has immediate vacancies in its Midlands office for qualified CIVIL ENGINEERS with special knowledge of modern bridge design and experience in construction. Applicants should give details of age, medical fitness, nationality, technical qualifications and experience, and when available.—Address replies to the Secretary, Braithwaite and Co., Engineers, Ltd. (marking envelopes B.159), "The Moorings," Church Road, Great Bookham, Surrey. E8667 A

COMPANY OPERATING A MODERN CONTINUOUS CHEMICAL PLANT invites applications for the post of DEPUTY WORKS ENGINEER

Applicants should preferably be in the age range of 40–50 with mechanical engineering qualifications and experience. They must have energy, shop floor experience and a down-to-earth attitude realising that organisation and administration exists only to get things done and are not ends in themselves. Experience of chemical plant or refinery installation with continuous highly instrumentated process plant where scheduled maintenance methods are in operation would be an advantage.

The post is permanent and offers an interesting career in agreeable surroundings.

Excellent terms of employment, including pension scheme.

Applications, giving full particulars, including age, experience and qualifications, should be addressed to BOX No. E8660, "The Engineer."

A

CONCRETE TECHNOLOGIST required by Civil Engineering Contractor, to set up a concrete testing laboratory on the site of a major contract. Experience required is in the field of concrete mix design and quality control. The situation is intended to be permanent.—Applications, which will be treated in confidence, to be addressed to BOX No. A334, JACK ADVERTISING, 13, Bath Street, Glasgow, C2. E8677 A

CONSULTING ENGINEERS

SERVICES OF AN ENGINEER

Consulting Engineers require the services of an ENGINEER to supervise the construction, in West Africa, of 132kV and 66kV overhead lines.

Applicants must be Corporate Members of one of the Senior Institutions, and have had recent experience in overhead line construction.

Salary will be at the rate of £2350 per annum, with free quarters and medical attention. First-class passages, liberal leave, eighteen-month tours.

Applications, giving full particulars, within fourteen days to

PREECE, CARDEW & RIDER,
8, 10 and 12, Queen Anne's Gate,
Westminster, London, S.W.1.

E8644 A

CHIEF DRAUGHTSMAN required for small but active D.O. engaged on special industrial heating equipment—Ovens, Furnaces, Impregnating Plants, &c. Good prospects for capable man with sound engineering background and experience of fabrication and sheet metal construction. Housing available. —Application in confidence, stating age, experience, salary level to Technical Manager, Barlow-Whitney, Ltd., Bletchley, Bucks. E8611 A

CHIEF MECHANICAL ENGINEER required by The National Coal Board's Production Department at their London Headquarters. He will be responsible for advising the Chief Engineer (Production) on general aspects of mechanical engineering at collieries, and for the supervision of engineers engaged on that work. Sound training in mechanical engineering together with considerable experience of engineering problems in coal mines, including at least three years as a senior mechanical engineer covering a number of collieries, are essential. Appointment is superannuable and salary will be according to the qualifications and experience of the successful candidate, but not less than £2250 per annum.

Write stating age, education, qualifications and experience to Staff Department, National Coal Board, Hobart House, London, S.W.1, marking envelope X.1256, before 8th October, 1958.

E8647 A

DESIGN DRAUGHTSMAN : A senior man with good engineering experience is required for a Chief Mechanical Engineer's office in Central London. A sound practical training and knowledge of engineering services is essential. The work entails handling projects from the drawing-board through to construction and running in for production. Salary will be from £850 p.a., plus lunches and an annual bonus, according to age, experience, &c.—Write, giving full details of age, qualifications, experience, &c., to BOX No. E8607, "The Engineer." A

DESIGNER/DRAUGHTSMEN—preferably experienced in design of jib cranes, &c. The positions offered are due to expansion of the firm's activities ; would be permanent, progressive, and would carry salaries commensurate with experience. Pension scheme. Five-day week.—Apply : Chief Draughtsman, Clyde Crane and Engineering Company, Mossend, Bellshill. E8575 A

DRAUGHTSMAN, aged 28–35, required for interesting and varied chemical plant construction. H.N.C. or equivalent and/or experience in fabrication work, particularly in stainless steel, an advantage. New Town housing available. Pension, life assurance and sickness pay schemes operating.—Applications, stating age, details of career to date and salary required, to the Personnel Officer, The A.P.V. Co., Ltd., Crawley, Sussex. E8682 A

BOOKS and PUBLICATIONS

The Calculations of Deformations of Welded Metal Structures

BY N. O. OKERBLOM

An addition to the current series of translated Russian technical books issued by the Department of Scientific and Industrial Research. Intended for engineers and designers in industry the book describes approximate methods of calculating distortions produced during fabrication of various welded metal structures and machinery. Illustrated with many text figures.

Price **15s.** (*post* 10*d.*)

HMSO

from the Government Bookshops or through any bookseller

PULSE AND TIME-BASE GENERATORS

By D. A. Levell, M.Sc., A.M.I.E.E. Gives a thorough, yet concise, survey of the theory and design of circuits that have been used to generate pulse and time-base waveforms. These circuits are used extensively in radar, television, and electronic instrumentation, so that the book will prove to be of value as a source of technical information for electronic equipment designers and students of electronic engineering. 25/- net.

PRESTRESSED CONCRETE

By P. B. Morice, B.Sc., Ph.D., etc., and E. H. Cooley, M.A. (Cantab.), etc. This new book gives a comprehensive treatment of both the theory and design of prestessed concrete structures and the practical problems involved in its use. The subjects include the elastic and collapse analyses of simple and continuous beams as well as analyses of more complex structures. 57/6 net.

PRACTICAL ENGINEERING METROLOGY

By K. W. B. Sharp, B.Sc., A.M.I.Mech.E. One of the few books to cover the basic principles of the subject. It deals chiefly with the fundamentals, describes a variety of methods and the accuracy to which measurements can be made, and covers existing examination requirements. 30/- net.

PITMAN BOOKS *Parker St., Kingsway, London, W.C.2*

New Books

HEAT EXCHANGERS

By W. HRYNIZAK, D.Sc., Dip. Ing.

63*s.*

This book is concerned directly with heat transfer apparatus and the best way of designing and fitting it into a gas turbine so as to obtain, depending on its applications, an economical unit. The manner in which the thermodynamical optimization of the gas turbine air preheater has been treated will be of particular interest in connection with supercritical steam cycles and nuclear power applications.

The book will supply an authoritative and long felt need to the engineer and will be of much interest to the physicist who is more and more becoming involved in direct applications of thermodynamics.

FLUID MECHANICS for ENGINEERS

By P. S. BARNA, M.E., A.F.R.Ae.S.
N.S.W. University of Technology 57*s.* 6*d.*

In this single volume adequate coverage is provided for students studying for a degree or diploma in Mechanical or Civil Engineering, and parts will be found equally useful for Higher National Certificate Courses.

Emphasis is upon the broad representation of the fundamentals and the subjects covered include fluid statics, fluid motion, wing theory, centrifugal pumps, and hydraulic turbines. A large number of examples with complete solutions are given and these have been carefully selected to illustrate the preceding theory.

AUTOMATIC MEASUREMENT of QUALITY in PROCESS PLANTS

Edited by THE SOCIETY OF INSTRUMENT TECHNOLOGY

50*s.*

These edited papers of The Society of Instrument Technology 1957 Conference provide a valuable and objective survey of the various techniques available for quality control in process plants. The papers fall into two complementary groups ; those covering a survey of the experience which has been gained with the wide variety of control instruments already in general use, while the second group explores the potential plant application of analytical techniques currently in use only in the laboratory.

Butterworths Scientific Publications

88 Kingsway, London, W.C.2

SITUATIONS VACANT

DAVY AND UNITED ENGINEERING COMPANY, LTD. invite applications for the position of ASSISTANT CIVIL ENGINEER. Must be familiar with the layout of heavy reinforced concrete foundations and services for Rolling Mill Plant and Building forming part of major steelworks construction projects. The position offers excellent prospects to a man having minimum qualifications of H.N.C. and preferably having passed Parts 1 and 2 of the examination for associated Membership of the Institution of Civil Engineers.

Good conditions, contributory superannuation scheme, existing holiday arrangements honoured.—Apply in writing with details of age, experience, qualifications and salary range in confidence to :—

Personnel Department,
DAVY AND UNITED ENGINEERING COMPANY, LTD.,
Darnall Works,
SHEFFIELD, 9.

E8646 A

DRAUGHTSMEN required by N.C.B.'s Production Dept. in London. DESIGNER-DRAUGHTSMAN, experienced in the design of mechanical equipment (including mining machinery), mechanical handling equipment and fabricated work, with sound technical education and practical training. H.N.C. qualification is desirable. ENGINEERING DRAUGHTSMEN (2 posts). Applicants should have a knowledge of mechanisms and mechanical handling equipment, experience of mining machinery would be an advantage. O.N.C. or equivalent qualification is desirable. Appointments superannuable and salaries within ranges £823–£956 and £774–£897 respectively.—Write to Staff Manager (X.1259C), National Coal Board, Hobart House, London, S.W.1, for application forms, which should be returned by 8th October, 1958. E8666 A

DRAUGHTSMEN, SENIOR, wanted for firm in North Staffordshire, with mechanical and steel structural experience. Good wages offered with assistance for housing accommodation. Contributory pension scheme.—BOX No. E2101, "The Engineer." A

ENGINEER, with First Class M.O.T. Steam Certificate, required by British company for charge of palm oil mill in Malaya. Remuneration commensurate with ability and experience. Applicants should be not more than 35 years of age, and have served a full apprenticeship in mechanical or marine engineering.—BOX No. E8686, "The Engineer." A

ENGINEERING GRADUATE required for a Senior position in the Power Jets' Consultancy Department at Farnborough, Hants. Experience of aerodynamic design and testing of turbo-machinery essential. Favourable superannuation and excellent working conditions.—Fullest details in confidence to the Secretary, POWER JETS (R. & D.), Ltd., 25, Green Street, London, W.1. E2107 A

ESTIMATOR
required for the
ENGINEERING DIVISION of
BRITISH CELLOPHANE, LIMITED,
Bridgwater, Somerset

Applicants must have served a general engineering apprenticeship followed by Drawing-Office experience and should hold at least an Ordinary National Certificate in Mechanical Engineering ; those with suitable background but without experience of estimating would be considered for training. The duties comprise estimating from drawings or from site inspection, of the material and labour required, for the execution of work on both maintenance and new construction of plant in a chemical factory.
Applications should be addressed to the Personnel Officer.

E8689 A

IF YOU ARE YOUNG, ambitious, of good education and address, with an alert mind and sound intellect, an old-established firm of machine tool manufacturers can make use of you. They are offering an exceptional opportunity to a young man of outstanding ability to Train for a Senior Management position in the company. Reliability, dependability, sound technical judgment is a requisite for this post. —Write to BOX No. E2103, "The Engineer," for form of application. A

METHOD STUDY ENGINEER required by N.C.B.'s Production Department in London. Duties include assisting in the introduction of Method Study techniques and lecturing on training courses and involves some travelling. Applicants should possess a recognised mining engineering qualification. Experience of Method Study, though not essential is very desirable but training will be given to the successful candidate lacking this experience. Appointment (superannuable) and salary according to qualifications and experience within inclusive range £1350–£1964.—Write to Staff Dept. (X.1255C), National Coal Board, Hobart House, London, S.W.1, for application form which must be returned by 8th October, 1958. E8648 A

POLLARD BEARINGS, LTD.,
Ferrybridge, Knottingley, Yorkshire.
TECHNICAL SALES ENGINEERS

Applications are invited from suitably qualified technicians for the above posts, which offer wide scope for initiative in furthering the application and sale of Ball and Roller Bearings. Successful applicants would be required to give advice and make recommendations direct to customers.

H.N.C. standard and previous experience in the Ball and Roller Bearing Industry desirable but not essential. State full details of experience, age and remuneration expected.—Address replies to General Manager, marked "Confidential."

E8655 A

Classified Advts. continued on page 118

COMPANY MEETING

POWELL DUFFRYN LIMITED

The Annual General Meeting of Powell Duffryn Limited was held on September 17, in London, Sir Henry Wilson Smith, K.C.B., K.B.E. (the Chairman) presiding.

The following is an extract from his circulated statement :

From the trading point of view, 1957/58 was a difficult and, to some extent, a disappointing year. In the last few years there has been a steady and satisfactory progression in Profits on Trading. This progress has now been interrupted with Trading Profits for 1957/58 of £1,832,000, that is a reduction of £204,000 on the previous year's figures and a level slightly below those of two years ago.

Apart from the impact on our Group of general economic conditions, it should be remembered that, despite the growing diversification of our interests, the coal distribution business of our Group is still the dominant contributor to trading profits. Both at home and abroad, 1957 was a difficult and uneven trading year for an organisation connected both with home and international coal trade. I do believe, however, that the events of 1957 have shown the ability of our Group to maintain a high level of coal tonnage and income even under adverse conditions. I also believe that the circumstances in which we now operate justify the policy of diversifying our activities.

GROUP ACTIVITIES

In the course of his review of Group activities, the Chairman said : Last year the interests of STEPHENSON CLARKE were affected by the reduction in the home consumption of coal with the inevitable reaction on profits. It is, however, satisfactory to report that the earnings of the Stephenson Clarke Fleet were not adversely affected by the substantial fall in deep sea freights as the bulk of the fleet operates in the Coastwise Trade of Great Britain, where freights have remained relatively stable. The sale of fuel oil by Stephenson Clarke is progressing steadily.

Having outlined the reasons for the downturn in profits of the CORY BROTHERS ' Companies, the Statement continued : The year was not without its encouraging features. Oil storage activities at Barry and Ipswich continued their upward trend.

1957 was not an easy year for the timber business. Yet the home Companies importing timber, and the Companies exporting from Sweden and Finland, did manage to achieve creditable results.

CAMBRIAN WAGON & ENGINEERING COMPANY has had a very busy and profitable year— in fact, the best in its history. Prospects for the current calendar year also look reasonably good. There is, however, serious uncertainty about the wagon-building, repair, and conversion programmes of the British Transport Commission which makes it important to press on with the development of additional lines of business, such as the construction of storage tanks which now makes a useful contribution to turnover and profits. Internal reorganisation has improved the technical and sales side of this Company for the tasks that lie ahead of it.

POWELL DUFFRYN CARBON PRODUCTS is another Group Company to be affected by the credit squeeze and the more cautious approach to projects involving capital expenditure. Sales of the traditional Delanium plant for the chemical engineering industry have remained more or less static. Certain expenditure, which is as yet unremunerative, has been incurred on various development projects, and especially on those connected with the use of graphite in the nuclear energy sphere. Some of this work has opened up interesting possibilities over and above the basic contribution of this Company in the machining of graphite for the General Electric Company. That machining work should begin in the last months of this year. We are fully prepared for it, and indeed for any further comparable work of the same kind. I am also still hopeful that various contacts which we have in the field of nuclear energy may lead to larger commercial operations within the skilled competence of our Company. In these circumstances, I am glad to say that we have been able to retain Professor J. M. Kay as a consultant to our Group. He is a well-known authority in the sphere of nuclear energy and is the head of the nuclear energy department of the Imperial College of Science and Technology in London.

WEATHERFOIL HEATING SYSTEMS has again had a satisfactory year, not only with its heating installations in schools and other buildings, but also with its sales agency for Dravo oil fired space heaters. The immediate forward order book remains in healthy condition.

RHYMNEY ENGINEERING COMPANY, owned jointly by International Combustion and Powell Duffryn, has not had an easy year. Its profits remained at a low level, and the partners are taking no dividend this year. It is, however, comforting that the order book has increased and that the prospects are steadily if slowly improving. The works at Rhymney, with the completion of the approved development plan, are in good shape to undertake the substantially greater volume of work which we expect to obtain.

POWELL DUFFRYN TECHNICAL SERVICES has continued to undertake with success a number of important overseas assignments.

Commenting on the future, the statement concluded : Basically I do believe that most of our difficulties are of a temporary nature. When, as I expect, they disappear, and when the plans laid in recent years, and still being implemented, come into full operation, I have no doubt that the Group will go forward once more.

The report and accounts were adopted.

SITUATIONS VACANT

MECHANICAL ENGINEER required by consulting engineers in London office for project investigations of an advanced nature in electric power generation. Degree and/or membership of Engineering Institution essential.—Write, KENNEDY AND DONKIN (HJP/20), 12, Caxton Street, S.W.1.

E8695 A

IMPERIAL CHEMICAL INDUSTRIES, LIMITED,
Alkali Division,
Winnington, Northwich, Cheshire,
has vacancies for the following :—

(a) RESEARCH ENGINEER
Candidates, aged 23 to 35, should possess an Honours Degree in Mechanical Engineering and have had training in workshops and drawing-office. Experience in industry is also desirable, but an interest in research and engineering progress is essential.

(b) FUEL TECHNOLOGIST
Candidates, aged 25 to 35, should possess a Degree either in Fuel Technology or Chemical Engineering (with a fuel bias), and have had 3 or 4 years' experience with coal-burning industrial furnaces.

Starting salary in accordance with age and experience. Assistance with housing and limited removal expenses for married men. Contributory pension fund and profit-sharing scheme.—Write for official application form to Staff Manager.

E8670 A

POWER RECTIFIER DESIGN

A large manufacturing firm in the Midlands requires electrical engineers to assist in development and design of high-power rectifier equipments, in a rapidly growing Department handling rectifiers of both mercury arc and semi-conductor types for applications of all kinds. Work offers scope for wide experience and interest, with good salary and prospects. Previous rectifier experience not necessary, but a degree or equivalent, and some practical experience, are desirable. Good residential district with excellent educational facilities and ample housing available.—Apply with full particulars to BOX No. E8526, " The Engineer."

A

PRODUCTION MANAGER
required by
NORTH BRITISH LOCOMOTIVE CO., LTD.,
Glasgow, to take complete charge of processing, rate-fixing, time study and jig and tool departments. Candidates must have held similar position in heavy engineering and preferably should have experience of fabrication and welding.—Apply to Engineering Director, stating details of education, practical and technical training, positions held, salary required.

E8649 A

REPRESENTATIVE, age 25–35, required for Midlands and Southern Counties, by flexible tube manufacturers. Previous experience and contacts with engineering concerns desirable. Full particulars. —BOX No. E2102, " The Engineer." A

RESIDENT ENGINEER required for extension to Waterworks in Oxfordshire. Must be qualified and experienced in reinforced concrete construction, with some plant installation experience. Write.—BOX No. E2108, " The Engineer." A

SALES PROMOTION MANAGER

Applications are invited by an engineering firm in the Midlands, which is a member of a group of companies of international repute, for the post of Sales Promotion Manager whose responsibility it will be to develop the sale in the Home Market of machinery and equipment for the following industries.

Chemical, Rubber, Paint, Ink, Ceramic, Powdered Metallurgy, Vitreous Enamelling, Paper Coating, Plastics &c.

Duties will include complete responsibility for planning and executing of sales campaigns involving close co-operation with manufacturing and technical staffs.

Candidates should be between thirty-five and forty-five years of age and should preferably hold an engineering degree or equivalent qualification and have had previous experience of market research and sales development administration in the industries referred to above.

The commencing salary for this post, which offers excellent prospects of advancement, will be within the range of £1500 to £2000 per annum.

Full particulars of age, qualifications and experience should be sent to BOX No. 1965, c/o Charles Barker and Sons, Ltd., Gateway House, London, E.C.4.

E8645 A

SALES ENGINEER.—We seek a Technical Representative for N.E. and Scotland, around 27/30, not necessarily with previous sales experience, but possessing alertness, persistence and integrity, which will be well rewarded by good basic salary, commission, car, expenses, pension, by progressive engineering company. Full details, please, in confidence. —BOX No. E2099, " The Engineer." A

SENIOR MECHANICAL HANDLING DESIGNERS required in Bristol, preferably with colliery equipment experience. Salary £950/£1100 per annum.—BOX No. E8555, " The Engineer." A

SHIPBUILDERS require ASSISTANT to Sales Manager in their London Office. Good education and pleasing personality essential with general knowledge of ship construction and machinery layouts, although only a superficial knowledge of ship design would be adequate. Additional experience in engineering other than marine would be an advantage. State age, technical qualifications, experience, existing salary and salary required.—BOX No. E2104, " The Engineer." A

SIR ALFRED McALPINE & SON, LTD., have vacancies for STRUCTURAL DESIGNERS/DRAUGHTSMEN in their DESIGN DEPARTMENT at Hooton. Applicants should possess a H.N.C. in Building (Structures) or Civil Engineering, or possess similar qualifications. Preference will be given to applicants who have had experience in the design and detailing of reinforced concrete structures. —Apply in writing to the Head Office at Hooton, Cheshire. E8652 A

TECHNICOLOR LIMITED requires the services of DESIGN DRAUGHTSMAN for the development of plant, mechanisms and machines used in film processing ; previous experience in this field not essential, but applicants must have good technical qualifications and knowledge of tool-room practice.—Write full details, age and salary required, to Personnel Manager, Technicolor Limited, Bath Road, West Drayton, Middlesex. E8679 A

THE BAHRAIN PETROLEUM COMPANY, LIMITED
STORES DEPARTMENT
ASSISTANT WAREHOUSE SUPERVISORS

Applications are invited for these positions from men of secondary education, 28 to 35 years of age, who have had a career in storekeeping, reaching supervisory positions involving the control of 30 or 40 men and up to 20,000 stock items, mostly of a heavy nature connected with engineering or heavy process plant, previous experience with refinery stores being an advantage. Duties cover receipt checking, labelling, stacking or binning, protecting and issue.

The salary would be in accordance with qualifications and experience, in addition to which free air-conditioned accommodation and an adequate living allowance are provided. An initial kit allowance, medical attention, paid local and home leaves are also provided, with participation in pension and provident fund schemes.

Apply in writing, quoting " STR " and with full particulars of experience, &c., to Caltex Services, Limited, Caltex House, Knightsbridge Green, London, S.W.1.

E8590 A

TO MEET AN EXPANDING PROGRAMME of development, a large organisation with Headquarters near London urgently needs more DRAUGHTSMEN. Experience in process plant is required in some of the work, but MECHANICAL DRAUGHTSMEN are also needed since the programme includes development work in novel processes essentially mechanical in nature. There are vacancies also for men with plant instrumentation knowledge. Good starting salaries will be paid and pension and profit-sharing schemes are in operation. Mortgage facilities are available and some help towards costs of removal.—Apply briefly to BOX No. E8642, " The Engineer," quoting Ref. D.1. A

VACANCY FOR FULLY-QUALIFIED ENGINEER, to take complete Charge of varied type Contracts in up to £10,000 medium general engineering class. Applicant must have a lively and versatile personality and be prepared to cover detailed design work. Applications must give details of qualifications, experience and salary requirements. Works located in South London.—BOX No. E2106, " The Engineer." A

WE WANT A FOREMAN TOOL MAKER to come in on the ground floor of a small, new project for manufacture of eyelets and other pressings to close tolerances in special alloys.

The man selected will be a potential Departmental Manager and will have considerable latitude in the selection of equipment and personnel to build up his department.

Only those who have the energy to make a success of such an assignment need apply. Other qualifications are widespread experience in tool design, manufacture and operation, an awareness of modern methods and, the ability to profit from published developments.

There is a full order book for the new work, with the assurance of continuity for the foreseeable future and expansion can be expected once the section has proved its capabilities.

The company will adopt a generous attitude regarding removal, should this be necessary. A pension scheme is in operation.

Applications, giving full details, please, to the Managing Director.—BOX No. E8678, " The Engineer."

A

WEST MIDDLESEX FIRM require immediately a competent ENGINEERING DRAUGHTSMAN, fully experienced in design of electro-mechanical devices.—BOX No. E136, " The Engineer." A

WORKS MANAGER required for medium-sized factory in the North of England engaged on light and medium engineering on a quantity basis. Candidates, who should be between the ages of 30 and 45 years, should have experience of modern management techniques and a successful record of achievement in this field. Salary £1500–£2000. Contributory pension scheme.—BOX No. E2098, " The Engineer." A

A SENIOR POSITION

offers itself in a well-established Technical Advertising Agency in the North ; the man required is of really high calibre with a first-class all-round record. He should be able to direct policy, and be creative of ideas and copy. Eventually he will be required to control staff and take responsibility for administration. Every help will be given by the directorate, whose intention is that such a man should rise to management as soon as possible. A background of technical and industrial experience is essential ; M.I.P.A. is desirable, but the Publicity Manager of a very large industrial organisation might prove to have most of the requisite abilities. The salary will be adequate ; it is the man that matters.—Applications in strict confidence and with fullest details to BOX No. E8687, " The Engineer."

A

SMITHS MOTOR ACCESSORY DIVISION

SENIOR DESIGNERS

Required to undertake design work on mass produced instruments and light mechanisms from specification stages.

Suitably qualified applicants will have had several years' light precision engineering and design experience, an apprenticeship or equivalent.

Excellent working conditions and a four-figure salary make employment with this Company an attractive proposition.

Write in confidence to the :—

Staff Manager,

S. Smith & Sons (England) Ltd.

Cricklewood Works, London, N.W.2.

Quoting ref : SM/131.

E8671 A

WILLIAM DOXFORD & SONS (ENGINEERS) LTD., SUNDERLAND

invite applications for the position of

PLANT ENGINEER

The post is a Senior one and will carry responsibility for the installation and maintenance of Plant and Buildings and the planning of future developments.

No precise age limits are set for this appointment, but a man of experience and judgment is required with a methodical approach and the administrative ability to complete work to authorised budgets. He will control a Staff of approximately forty.

An Apprenticeship in Heavy Engineering, professional qualifications and a proven record as a Plant Engineer in a supervisory capacity are essential requirements. Electrical knowledge will be a desirable advantage.

This appointment, which will carry a suitable salary with Pension and Life Assurance, has been advertised within the Company.

Preliminary interviews will be conducted by :

Production Engineering, Ltd.,
Cross House, Westgate Road,
NEWCASTLE UPON TYNE, 1.

to whom applicants should immediately send full details. E8697 A

THE GENERAL ELECTRIC COMPANY LIMITED
ATOMIC ENERGY DIVISION

SENIOR MECHANICAL ENGINEER

A vacancy occurs in the Division for a SENIOR MECHANICAL ENGINEER to lead a team of Engineers and Draughtsmen concerned with the overall design and layout of reactor plant for nuclear power station projects.

Applications are invited from men with an engineering degree or equivalent and several years of design or operating experience in fields involving heavy plant running at high temperatures and pressures, for example :—

1. Large pressure vessels.
2. Chemical plant and oil refineries.
3. Boilers.
4. Steam or gas turbines.

The position is a responsible one and an attractive salary will be offered to suitable applicants.—Write giving details of age, experience and qualifications to Personnel Manager (P.L.), The General Electric Company, Ltd., Erith, Kent.

E8658 A

A SENIOR STANDARDS ENGINEER

is required with a knowledge of valves, pipework and general chemical plant and of B.S. and A.S.M.E. specifications.

It is desirable that applicants should have had previous experience in a Standards Department but this is not essential, provided there is previous practical and design experience on chemical or petroleum plant. Membership of a professional institution is desirable.

The appointment carries a good commencing salary and excellent conditions of service.

Assistance may be given with removal and legal expenses, if it should be necessary for the successful applicant to move his home.

Applications, giving full details of age, qualifications, experience and present salary to :

The Personnel Manager (GH/18),
BRITISH OXYGEN ENGINEERING LTD.
Angel Road, Edmonton, London, N.18.

E8672 A

DESIGNER/DRAUGHTSMEN, MECHANICAL

are required by MICHELIN TYRE CO., LTD., for interesting project work at their Stoke-on-Trent Factory.
Applicant should be over 25 years of age, have served a sound apprenticeship in this country and possess H.N.C.
Good design experience is required in one of the following :—

(a) Works services, involving steam, pneumatic and hydraulic applications. (For this a Heat Engines or Thermodynamics endorsement is desirable.)

(b) Layout and installation of medium to heavy mechanical handling plant (Roller, belt and chain conveyors).

Appointments are permanent and pensionable and a 5-day, 40-hour week is in operation. Salary according to experience and qualifications. ASSISTANCE GIVEN WITH HOUSING IF NECESSARY. LODGING ALLOWANCE OF £4 P.W. FOR MARRIED MEN PENDING REMOVAL. REMOVAL EXPENSES PAID.

Please write to :

MICHELIN TYRE CO. LTD.
(SPA DEPT.), STOKE-ON-TRENT, STAFFS.
quoting reference B/172/251/E.

E8657 A

SITUATIONS VACANT

SMITHS MOTOR ACCESSORY DIVISION

SENIOR MECHANICAL AND ELECTRICAL ENGINEERS

We need, in our Development Departments, Senior Mechanical and Electrical Engineers for work on instruments and mechanisms.

Applicants should be suitably qualified, will probably have served an apprenticeship and progressed through workshop and Drawing Office to development work associated with mechanical or electro-mechanical mechanisms.

Excellent working conditions with a four-figure salary make employment with this Company an attractive proposition.

If you are interested and suitably qualified, write in confidence, with details of age, experience and present salary, to :—

The Staff Manager,
S. Smith & Sons (England) Ltd.
Cricklewood Works, London, N.W.2
quoting ref. SM/130.

E8669 A

ASSISTANT DESIGN ENGINEER

required by Centrifugal Pump Manufacturers in the North Midlands.

Applicants, aged 30 to 40, must have comprehensive experience in this field, with good knowledge of Hydro-Dynamics, and Technical Education up to A.M.I.Mech. E. Standard or equivalent.

The successful candidate must be capable of advising on pump applications, and be able to handle the design problems connected with specification contracts and new development work. The appointment is progressive, and interviews can be arranged for week-ends, travelling expenses being paid.

Canteen facilities and Staff Pension Scheme.

Please reply, giving full details of age, (experience, and salary required to BOX No. E8592, " The Engineer."

A

THE RICHARDSONS WESTGARTH GROUP

The recently formed Engineering Division of the Group requires additional

SENIOR MECHANICAL ENGINEERS

to initiate, and be responsible for, individual projects of importance in the general engineering field.

The Group is expanding its activities in nuclear, marine and general engineering by application of the latest techniques to a range of basic engineering problems involving turbo-machinery, heat exchange, &c.

The work is challenging and can appeal only to those with good engineering training who have the necessary versatility to respond to a stimulating environment.

Write, in confidence, to the Group Personnel Officer, Richardsons Westgarth and Co., Ltd., Northumberland Engine Works, Wallsend, Northumberland, quoting ref. No. E.5 G.

E8685 A

SENIOR DRAUGHTSMEN DESIGN ENGINEERS and DESIGN DRAUGHTSMEN

are offered progressive posts at

STEWARTS and LLOYDS LIMITED · CORBY

. . . one of the largest integrated Iron, Steel and Steel Tube Works in Europe

MECHANICAL ENGINEERING

1. Department of New Development. For the design and development of plant and equipment. Applicants must have sound knowledge of heavy engineering, preferably in an Iron and Steel Works, and considerable experience of design work.

2. Tube Works Drawing Office. Senior Draughtsmen for layout, maintenance and improvement of plant and equipment. Applicants must have H.N.C., along with sound Drawing-Office experience in heavy engineering.

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Manager/Personnel,
STEWARTS AND LLOYDS, LIMITED,
Corby, Northants.

E135 A

SITUATIONS WANTED

ENGINEER, aged 38, Higher National (Production) First Combined M.O.T. Certificate, M.I.Mar.E., experienced in plant layout, design, inspection of pressure vessels, planned maintenance, administration, available immediately.—BOX No. E2100, " The Engineer."

B

47 YEARS' MECHANICAL ENGINEERING EXPERIENCE OF SALE. I am equally at home in Works, Design Office and Executive Office, in heavy and light engineering. I am seeking a post which will use my experience to the full and pay accordingly. West London to Reading area preferred.—BOX No. E2109, " The Engineer."

B

FOR HIRE

LATTICE STEEL Erection Masts (light and heavy), 30ft. to 150ft. high, for immediate hire.—Bellman's, 21, Hobart House, Grosvenor Place, S.W.1 ('Phone, SLOane 5259). E103 K

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INVENTOR OF RETRACTING UNDERCARRIAGE, car trailer, hand or hydraulic operated, wishes to produce and Market for Home and Overseas. Sealed Patent, June, 1957. Prototype and drawings.—Kirkham, 295, Wells Road, Bristol. E8656 O

BUSINESSES and PREMISES

SMALL ENGINEERING BUSINESS FOR SALE in London as going concern. Engaged mainly on sub-contract work in electronic field. Fully equipped and staffed for manufacture of machined components to A.I.D. standards. Leasehold property ; 2500 sq. ft. Full order book.—BOX No. E2105, " The Engineer."

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Prompt service.
Competitive prices.
Please write :
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SUB-CONTRACTING

CASTINGS.—We can save your porous castings, ferrous or non-ferrous, by an approved impregnation process ; sample castings treated ; A.I.D. approved. —Recupero, Ltd., 66, South Harrow Viaduct, Harrow, Middlesex ('Phone, Byron 1178). E109 MW

KELLERING AND CAM PROFILING capacity up to 8ft. by 6ft. or 6ft. diameter.—ARMYTAGE BROS. (KNOTTINGLEY), Ltd., The Foundry, Knottingley, Yorkshire (Telephone : Knottingley 2743/4). E116 MW

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AND

MECHANICAL TESTING

An experienced Stress Office has capacity for aircraft and general engineering work covering design and detail stressing to A.P.970, B.S.1500 and A.R.B. requirements, check stressing and Type record preparation.

MECHANICAL and HYDRAULIC TESTING FACILITIES AVAILABLE

Apply to Chief Technician, c/o S.A., BOX No. E8676, " The Engineer."

MW

DIRECTORS

MANAGING DIRECTOR of professional engineering company is available, PART-TIME or OCCASIONALLY, to advise on mechanical engineering design or development policy and projects.—BOX No. E2110, " The Engineer."

Q

MISCELLANEOUS

TIME RECORDERS, Sales, Rentals, Service, Telephone Hop 2239.—Time Recorder Supply and Maintenance Co. Ltd., 157–159, Borough High Street, London, S.E.1. E110 I

MACHINERY Etc. WANTED

WANTED, Machines of all Types.
CASH PAID.
Norman E. Potts (B'ham), Ltd., 130, Moseley Road, Birmingham, 12. VIC. 1278, 1279, 1270, 0856.
E104 F

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Unused 4000-ton HYDRAULIC HEAVY PLATE FORMING and BENDING PRESS, table 18ft. by 10ft., weight 380 tons.
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650-ton DOUBLE-ACTION DRAWING PRESS, by Lake Erie, bed 7ft. 6in. by 6ft. 8in., with self-contained pump unit.
MANY OTHER HYDRAULIC PRESSES OF ALL TYPES

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E8674 G

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SPECIAL ALTERNATORS

kVA	Maker	C.P.S.	Volts	Phase	Speed
	Garbe				
200/400	Lahmeyer	300/500	230/400	3	900/1500
156	B.T.H.	100/125	100	3	1200/1500
10	L.D.C.	200	220	3	1500
1·5/4·0	Stamford	60/100	115/230	1	1000/3000
3	Newton	1150	115/230	1	3000

Selection of stock only, please send your enquiries.

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18FT. BY ¼IN. RHODES PRESS BRAKE for sale (or 10ft. by 3/16in.), 150 tons capacity, motorised 400/3/50, friction clutch, motor adjustment to ram, 90 deg. forming tool 10ft. 2in. long, and bottom die with 1¼in. and 1¼in. openings, bed and top beam solid steel, 18ft. 1in. long, between uprights 10ft. 2in., stroke 5in., die space 12in.. Weight about 20 tons.—F. J. Edwards, Limited, 359, Euston Road, London, N.W.1, or 41, Water Street, Birmingham, 3.
E8694 G

FOR SALE

FRED WATKINS (ENGINEERING), LTD.

STEAM BOILERS.—Cochran Vertical (New), 8ft. 6in., 8ft., 7ft. 6in., 7ft. and 6ft. in dia., 100/150 lb. w.p.; reconditioned 8ft. 6in. down to 3ft. dia.; Economic 4ft. to 11ft. 6in. dia., including new 7ft. and 8ft. dia., 150, 180 and 200 lb. w.p ; 300 reconditioned Vertical Crosstube, all sizes.

AIR COMPRESSORS.—Broomwade 400, 300, 200 and 130 cu. ft.; all motorised ; Reavell Rotary Blowers, 2000 c.f.m., 3–2 p.s.i.

200 AIR RECEIVERS, stocked up to 9ft. dia., 100 to 500 lb. pressure.

ELECTRIC MOTORS.—150 Totally Enclosed and Flameproof Motors up to 100 h.p.

CRANES.—Mobile 10-ton Lorain, lorry mounted, 30ft.–70ft. extendable jib ; 6-ton and 4-ton Coles Diesel-Electric ; 3-ton Jones Super 40 (3) ; Neals 2-ton Diesel, 20ft. jibs (2) ; Derrick, 5-ton Butters Electric travelling type, 90ft. jib ; 5-ton Wilson Electric, 70ft. jib ; Steam Loco, 18-ton Brownhoist, 50ft. jib ; 10-ton Coles, 40ft. jib ; 8-ton Wilson, 35ft. jib ; 5-ton Smith, 50ft. jib ; 5-ton Cowans Sheldon, 50ft. jib ; 5-ton Grafton, 38ft. jib ; E.O.T. 40-ton Adamson, 42ft. span ; 20-ton Vaughan, 42ft. span (8) ; Goliath, 40ft. span, 60-ton Clyde, 40-ton Babcock, 10-ton Morris ; 5-ton Henderson, 24ft. 7½in. span, 1946 ; 5-ton King, 29ft. 3in. span ; 2-ton Morris, 18ft. span, 2-ton Smith, 34ft. span.

LOCOS.—Fowler Diesel, 150 h.p. (2) ; Ruston Diesel, 80/88 h.p., new 1942 ; Hunslet 0–6–0, 18in. by 26in., new 1944 ; Bagnall 14in. by 22in., two oil fired, one coal ; Peckett Steam, 7in. by 12in., 1941 ; also 3 miles track, 24in. gauge Bogies, Turnouts, &c.

STEEL PIPING.—50,000ft., 2in. Galvanised, new ; 60,000ft., 3in. black new ; 5000ft., 8in. seamless ; 1000ft., 12in. seamless ; 500ft., 14in. seamless ; 400ft., 18in. riveted ; 280ft., 21in. o.d. welded flanged ; 3800ft., 21in. seamless flanged ; 500ft., 24in. riveted ; 1450ft., 27in. o.d. welded flanged ; 216ft., 48in. riveted ; 216ft., 60in. riveted.

CAST IRON PIPES.—Large stocks all sizes up to 24in. flanged and s.s. Immediate delivery.

VALVES.—Exceptional Surplus Ministry Lot New Stainless Acid Cocks and Valves, over 5000, immediate delivery, below makers' prices. Large stock, all sizes, Parallel Slide Sluice, Gunmetal, Reducing and Check Valves. List on request.

STORAGE TANKS.—300 cylindrical and rectangular up to 12,000 gallons, for oil and petrol, also sectional steel and cast iron up to 50,000 gallons.

MACHINE TOOLS.—Scriven Plate Bending Rolls, 14ft. by ¼in.; Robertson Straightening Rolls, 8ft. 6in. by ¼in.; Berry Bending Rolls, 7ft. by ¼in.; Tangye 200-ton Hydraulic Vertical Straightening Press, 15ft. by 3ft. table ; Herbert 3ND Miller, 61in. by 15in. table ; Pels Punch and Shears, ¾in. capacity ; nine new 2 cwt. and 1 cwt. Pneumatic Hammers.

SLING ENGINEERING WORKS
COLEFORD, GLOS.
'Phone : Coleford 2271/2. E106 G

600

ECONOMIC BOILERS

TWO RUSTON and HORNSBY " Thermax " (wet back) treble pass, 10ft. 6in. diam. by 13ft. 6in. long, excluding smoke box and flue outlet, evap. 13,000 lb./hr., 200 p.s.i.
THREE FOSTER, YATES and THOM double pass, 9ft. 9in. by 15ft. 6in. by 20ft. 6in., evap. 12,000 lb./hr., 160 p.s.i.
TWO JOHN THOMPSON treble pass, 9ft. 6in. by 14ft. by 19ft., evap. 9500 lb./hr., 120 p.s.i.
THREE MARSHALL (Gainsborough) treble pass, 8ft. by 9ft. 6in. by 12ft., evap. 5000 lb./hr., 100 p.s.i.
All complete with usual fittings and mountings arranged for oil or solid fuel firing.

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E222 G

STANDARD GAUGE RUSTON 88DS SHUNTING LOCOMOTIVE. Tractive effort 9500 lbs. Completely overhauled and ready for work. Any trial or inspection.
3-TON ELECTRIC DERRICK CRANE ANDERSON GRICE, 80ft. Jib, in first-class order.
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E8634 G

FOR SALE

EFCO 25-ton capacity Electric Arc Tilting Furnace, complete with mains transformer, 11,000 volts, and all control gear. Furnace built 1940 and very little used.
Six 25-ton capacity Crane Ladles.
The above is offered for immediate sale at very attractive prices.
For full details apply BOX No. E8659, " The Engineer."
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HYDRAULIC PRESSES
HYDRAULIC PUMPS

Hydraulic Accumulators, Valves, Fittings, New and Second-hand. Complete installations.
All kinds of Hydraulic Equipment in stock.
THOMPSON AND SON (MILLWALL), LTD.
Cuba Street, Millwall, London, E.14.
East 1844/5.
E111 G

Classified Advts. continued on page 120

FOR SALE

SERVICE EDWARDS VALUE

CRAIG & DONALD Model 400/10 All Steel Motorised Double Geared Press Brake, of steel plate construction, pressure exerted 400 tons, forming capacity 10ft. by ¾in., depth of gap 12in., width between side frames 82in., stroke 4in., maximum daylight, stroke down adjustment up, 18in., arranged motor drive 440/3/50, air-operated treadle clutch, weight about 29 tons.

NEW STOELTING Pyramid Type Plate Bending Roller, motorised 400/440/3/50, capacity 10ft. wide by ¾in. mild steel, diameter of rollers, top, 9¾in., bottom, 7¾in., drop-end bearing for removal of completed cylinders, support rollers to bottom rolls, reduction gearbox drive to bottom rolls with multi-disc slipping clutches, motorised adjustment to top roller.

TWO BIGWOOD Type PBG. 4-Roll Motorised Plate Bending and Straightening Machine, three rollers set pyramid fashion for bending and additional fourth roller for flattening, arranged motor drive 440/3/50, capacity 4ft. by ¾in., length of rolls 53½in., weight approximately 90 cwt.

BESCO Open End Angle Iron Bending Machine Type M.14A, arranged motor drive, 380/420/3/50, bends up to 1½in. by 1½in. by ¼in. angles, rolling speed 15ft. per minute, complete rings easily withdrawn, will bend angles, tees, flats, rounds and squares, &c.

SCRIVEN Geared 7-Roll Plate Straightening Machine, capacity 5/16in. thick, size of rollers 74in. long by 6½in. diameter, arranged motor drive 400/3/50.

NEW BESCO 8ft. 4in. by 3/16in. Type HK All Steel Undercrank Open End Production Power Guillotine of steel construction, arranged motor drive, automatic hold-down, adjustable front and back gauges.

Photographs of the above are available.

MACHINE TOOLS, NEW AND USED, Of Every Description. Attractive Prices.

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Telephone : EUSton 4681–3771,
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BIRMINGHAM, 3.
Telephone : Central 7606–8. E207 G

FOR DISPOSAL

DRAG SCRAPER PLANT WITH SLIP RING MOTOR AND HYDRAULIC COUPLINGS FOR COAL STOCKING AND RECLAIMING

Beaumont Standard No. 3N Drag Scraper :

Average capacity ...	175 tons per hour over 170ft. approx.
Rope speed... ...	450ft. per minute
Rope diameter ...	1in.
Scraper capacity...	4 cubic yards
Winch size ...	No. 80
Clutch control ...	Remote (electro-mechanically)

ELECTRICAL EQUIPMENT

Lancashire and Crypto Totally Enclosed, Corcooled, Horizontal - Spindle, Squirrel Cage Induction Motor, cont. rated 400V, 3-phase, 50 cycles :

Output...	180 b.h.p.
Speed	988 r.p.m.
Frame size	E.T.R. 28M6
Amps.	237
Open circuit motor current	513 volts
Full-load motor current ...	158 amps.

New and unused. Date 1951.
'Phone : EALing 6688. Ext. 9. E8654 G

NEW OVERHEAD CRANES

60-ton Goliath, by Clyde, 40ft. span, 5-ton auxiliary ; cab control, 400/3/50.
40-ton Goliath, by Babcock and Wilcox, 40ft. span, 5-ton auxiliary ; cab control, 400/3/50.
40-ton Adamson, standard cab control, 42ft. 3in. span, 400/3/50.
30-ton Vaughan, 42ft. 3in. span, almost new.
10-ton Goliath, by Morris, 40ft. span, cab control, 22ft. lift, 400/3/50.
Surplus Unused Ministry Cranes, mainly still packed. Drawings on request. Inspection invited. Bargain prices about one-third of New.

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875kVA, 6·6kV, 3/50 pass-out condensing Steam Turbo-Alternator Set by FRASER & CHALMERS/G.E.C., steam pressure 180 p.s.i., 420 deg. Fah. temp., pass-out up to 10,000 lb./hour at 30 lb. pressure with condensing equipment and control gear.

675kW, 400/3/50, 4-wire back pressure type Steam Turbo-Alternator Set by BELLISS & MORCOM/BRUSH ELECTRICAL, steam pressure 150 p.s.i., 12 lb. back pressure with standard ancillaries and Alternator control gear.

400kW, 440/3/50, 4-wire Diesel Alternator Set ; speed 375 r.p.m., incorporating 675 h.p. oil engine by W. H. ALLEN coupled to English Electric Alternator with control gear.

1000 c.f.m. ALLEY & MACLELLAN vertical single-stage Air Compressor, 50 p.s.i., direct coupled to 160 h.p. CROMPTON PARKINSON auto-synchronous motor, 400/3/50, with control gear.

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MILWAUKEE J.H. VERTICAL MILLER

Speeds 20–1000 ; table 64in. by 13½in. ; Sliding head and rapid traverses.

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E8639 G

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Unused Ballast type, ram 15¼in. diam. by 20ft. stroke, cap. 160 g.p.m., w.p. 1500 lb. per square inch, casing 14ft. diam. by 20ft. deep.

Ballast type, ram 12in. diam. by 14ft. stroke, cap. 68 g.p.m., w.p. 1 ton per square inch, casing 14ft. 6in. diam. by 14ft. deep.

Ballast type, ram 8in. diam. by 12ft. stroke, cap. 26 g.p.m., w.p. 1500 lb. per square inch, casing 9ft. diam. by 14ft. 6in. deep.

Ballast type, ram 7¼in. diam. by 9ft. stroke, cap. 16 g.p.m., w.p. 1 ton per square inch, casing 10ft. 6in. diam. by 11ft. deep.

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FOR IMMEDIATE SALE.—One Heavy Duty Double-Ended Beam Bending and Straightening Machine by Smith Bros., capacity 16in., with Double Angle Cutters (not in use), motorised; One 18in. Slotting Machine by Butler, table 42in. diameter, admits 6ft., gearbox, motorised.—JOHN H. RIDDELL LTD., 62, Robertson Street, Glasgow, C.2. E2096 G

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METROPOLITAN-VICKERS 500 H.P. SLIP-RING ELECTRIC MOTOR, 196 r.p.m., 400/440/3/50 cycles, complete with control panel and reduction gearbox, giving a final speed of 8·1 r.p.m.
Motor and gearbox available separately if required.

JOHN CASHMORE, LTD.
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E120 G

600

VARIABLE SPEED DRIVES—400/440/3/50

H.P.	Maker	Type	Speed Range
270	B.T.H.	Schrage	370/95
0/225	Harland	Ward Leonard	0/1750
0/200	G.E.C.	Ward Leonard	0/1000
170/27·5	B.T.H.	Schrage	1000/400
0/150	Mather & Platt	Ward Leonard	0/520
0/33/33	Mawdsley	Ward Leonard	0/1000/1450

GEORGE COHEN,
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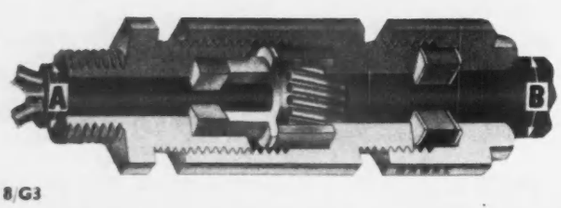
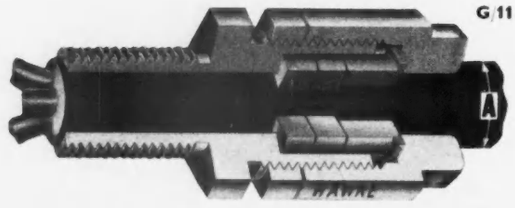


8/G3

G/11



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SALES BY AUCTION

		Main Location	*Auctioneers*
September 30 October 1	**Machine tools and miscellaneous stores**	**M.O.S. Storage Depot, Ruddington, Notts.**	**WALKER, WALTON & HANSON** (Dept. L), Byard Lane, Bridlesmith Gate, Nottingham. (Tel.: 47271.)
October 3	**Miscellaneous stores,** including :—	**Command Ordnance Depot, Coypool, Marsh Mills, Plymouth.** (Sale at Kinterbury House.)	**WOOLLAND, SON & MANICO** (Dept. L), Kinterbury House, St. Andrews Cross, Plymouth. (Tel.: 65356.)
	16,000 great coats, canvas, webbing, hessian, vests, boots, tables, chairs, settees, tool and twist drill grinders, pillar drills, accelerator pumps, electric wire and fittings, miscellaneous metal water fittings, asbestos sheets, M.T. tool kits, 8-ton road roller, etc.		
October 7	**Machine tools and miscellaneous stores,** including :—	**M.O.S. Storage Depot, Byley, Middlewich, Cheshire.** (Sale at New Islington Public Hall, Ancoats, Manchester.)	**J. H. NORRIS & SON** (Dept. L), 9, Albert Square, Manchester, 2. (Tel.: Blackfriars 8373.)
	Centre, screwcutting and capstan lathes, single and multi-spindle conomatic and automatics, surface and universal grinders, horizontal grinders, pedestal drills, woodworking machines, circular saw benches, power hacksaws, arc welders, pump units, Ransome & Rapier excavator, binoculars, electric and radio equipment, compressors, M.T. spares, tubular heaters, M.S. and C.I. pipes, bends and fittings, corrugated steel sheets, hardwood and plywood sheets, telegraph poles, hand tools, furniture, nuts, bolts, screws, washers, chemicals, paint, etc.		
October 14–15	**Vehicles and miscellaneous stores**	**Central Ordnance Depot, Bicester, Oxon.**	**MIDLAND MARTS, LTD.** (Dept. L), Market Square, Bicester, Oxon. (Tel.: 73.)
October 21–23	**Machine tools, vehicles and miscellaneous stores**	**M.O.S. Storage Depot, Royal Arsenal, Woolwich, S.E.18.**	**FULLER, HORSEY, SONS & CASSELL** (Dept. L), 10, Lloyd's Avenue, London, E.C.3. (Tel.: Royal 4861.)
October 29–30	**Miscellaneous stores**	Northern Command, Ordnance Sub Depot, **Barlow, Nr. Selby, Yorkshire.**	**BARTLE & SON** (Dept. L), 50–52, Merrion Street, Leeds, 2. (Tel.: 2.0898.)

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(a) *Catalogues* for the above auction sales 1s. 0d. each (P.O.'s only), obtainable *only* from the auctioneers shown above.

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E118 J

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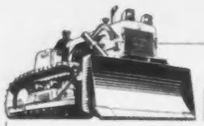

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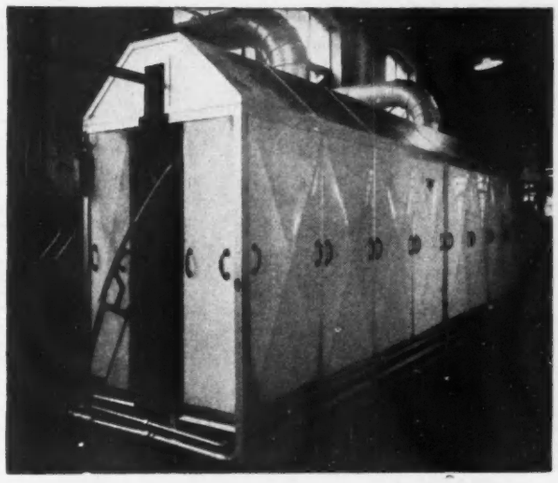

Why you should come to Aeraspray with your Finishing Problems of all kinds is well illustrated by our ability to help with Drying Problems. There are still many people unaware that, as Pioneers of Infra Red Drying our Experience will soon have covered Three Decades. ***Our illustration is of a recent plant for one of the larger manufacturers of quality automobiles.*** We also made the Dipping Tank for primer, Spray Booths for finishing cellulose, the conveyor system and, of course, Spray Guns and Ancillary Equipment.

● ***Write for Information Literature EI.58***

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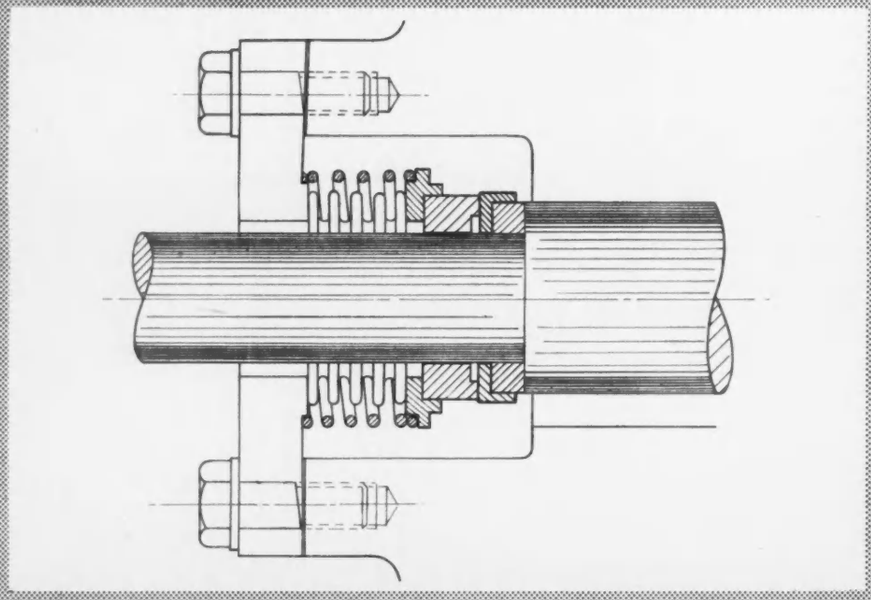
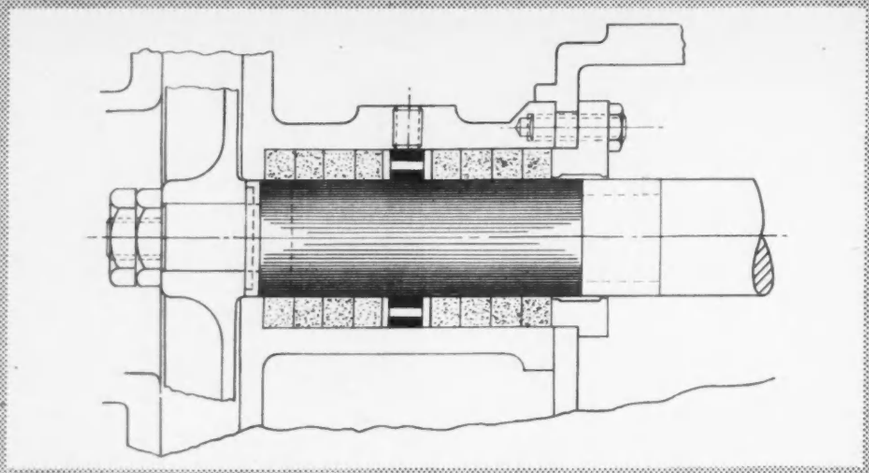


THE ANSWER TO WEAR PROBLEMS CAUSED BY ABRASIVE AND CORROSIVE CONDITIONS



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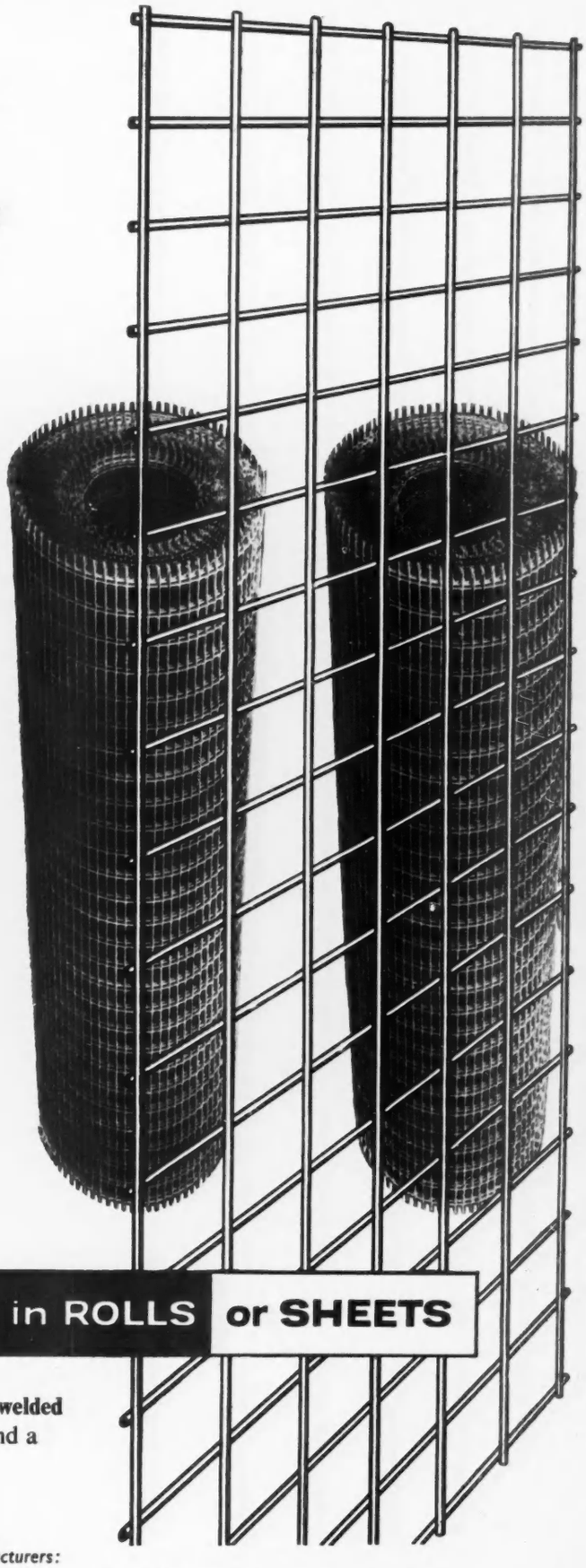

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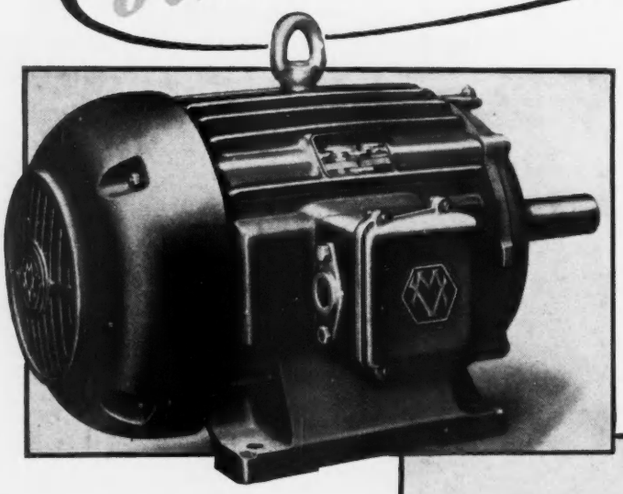
The Engineer

SEPTEMBER 26, 1958

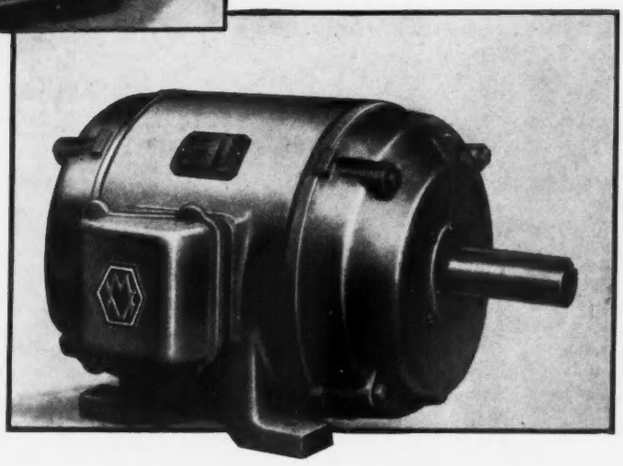
MOTORS *with* Standardised Dimensions



Type KN-B to BS2083/1956
TEFC ENCLOSURE
1-20 hp* (4-pole)

**Additional Ratings not included in BS2083 are also available up to 50 hp.*

With the introduction of the new BS2960/1958, squirrel-cage motors with Standardised Dimensions can now be supplied with VENTILATED as well as TEFC enclosures. Metrovick Motors designed and built to these specifications are known as Types KN-C and KN-B respectively.



Type KN-C to BS2960/1958
VENTILATED Enclosure from
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